Using Smartphones as Magnifying Devices: A Comparison of Reading Surface Finger Tracking and Device Panning

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ABSTRACT

Smartphones can be used as magnifying devices to compensate for low visual acuity. However, it can be challenging to pan both vertically and horizontally. To simplify panning we implemented a magnifier where the user moves the finger along the text on the reading surface instead of moving the device. A controlled experiment was conducted to compare finger-based panning with panning by moving the device. The results show that participants performed better with device-based panning and preferred device-based panning compared to surface finger tracking.

CCS CONCEPTS

• Human-centered computing → Accessibility → Accessibility technologies

KEYWORDS

magnification, reduced visual acuity, panning, smartphone

1. INTRODUCTION

Smartphones can serve as practical magnifiers for users with reduced visual acuity. They can replace both magnifying glasses for near reading of small print and binoculars for distance reading of information signs and public displays. State-of-the-art smartphone cameras offer high resolution, high refresh-rates, image stabilization, ability to capture images in conditions with limited lighting, and the ubiquitous smartphone is not attached to the same stigma as special purpose assistive technology.

One challenge with magnification technology is that the user must pan the magnified area both horizontally and vertically. Two-dimensional panning can be disorienting, and WCAG discourages horizontal scrolling allowing users to control scrolling along one dimension only. Clearly, the printed text in the physical world cannot be modified with the same ease as responsive web-content. Therefore, this study set out to explore if the panning experience can be improved by allowing the user to control the pan with the finger on the reading surface instead of moving the device. The user would hold the smartphone in a fixed position above the reading surface with one hand while controlling the pan by moving the index finger of the other hand by dragging it along the reading surface (see Figure 1)

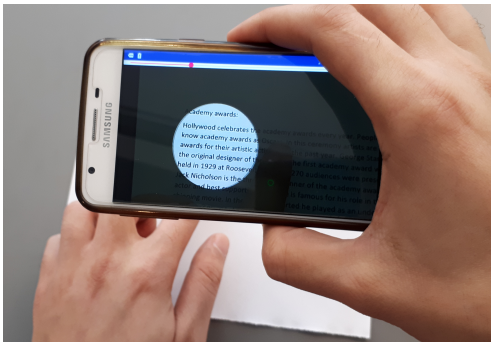

Figure 1: Panning by tracking the fingertip on the paper.

2. RELATED WORK

It has been pointed out that new magnifying technology does not necessarily improve the reading experience and therefore argue for magnifier usability studies [2]. More specific findings suggested that overlapping mode (the lens on top of the area to be magnified) works better than parallel mode where the lens is not overlapping this area [9]. Highlighting of the line being read has also been shown to aid readers [4].

A handful of studies have addressed hand-held magnifiers. It has been found that users find direct control of the zoom and pan with touch gestures easier to use than specific controls such as knobs and buttons [6]. Others have explored the use of magnification as part of an augmented reality configuration [8]. Image-based reflow of characters has also been use to reduce the panning task from two to one dimension [7] as it has been shown that text that has been adjusted to fit the display width (reflow) leads to higher usability scores and less nausea [5]. Other studies have addressed magnification implementation issues [1, 3].

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3. METHOD

A controlled within-groups experiment with panning mode as independent variable with two levels, namely finger-controlled panning and traditional device panning. Time to complete a reading task and preference for the panning technique were observed as the dependent variables. A total of $N = 10$ participants was recruited for the experiment (9 male, 1 female). Six of the participants were university students and four where software engineers (age 25-32). All were familiar with smartphones. None of the participants were visually impaired.

A magnifying application was developed in java for Android using the OpenCV image processing library (see Figure 1). This application uses image processing to track the position of the index fingertip and shows a magnified version of the captured image just above the fingertip. For the ordinary panning task, a fixed window with the same zoom level was configured. The experiments were carried out using a Samsung S5 smartphone with a 13 Megapixel camera (4128 × 3096 pixels), 30 frames per second with autofocus and image stabilization. The application achieved a display update rate of 18 to 21 frames per second. Only digital zoom was used.

A set of reading tasks were designed using text cards with questions. In order to answer the questions, the participant had to read the entire card. The cards where designed on various topics such as history, cities, and movies. Each card was printed in A5 landscape with a 12-point font size.

The presentation orders were randomized to minimize learning effects. The participants were asked to read all the text via the display. Reading task completion times were recorded using a stopwatch. After completing the tasks for each panning mode, the participants were asked about their subjective preference using a 5-item Likert scale. Each session lasted approximately 20 minutes. Results were analyzed using JASP 0.9.1.0.

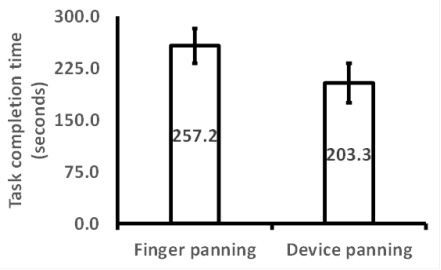

Figure 2: Mean task completion times. Error bars show SD.

4. RESULTS

Figure 2 shows the observed task completion times. Finger-based panning lead to a slower task completion time (M = 257.2, SD = 25.1) compared to device-based panning (M = 203.3, SD = 28.4) and a paired t-test shows that this difference statistically significant ($t(9) = 4.457$, $p = .002$, d = 1.410).

A similar result was observed for the participants subjective preferences as the median response for finger-based panning was 2 (dislike), while it was 3/4 (neutral/like) for device-based panning and a Wilcoxon signed rank test shows that these responses were significantly different (W = 2.0, $p = .029$).

5. DISCUSSION

Clearly the results are unexpected as the traditional panning using the device was both faster to use and preferred by the participants. Possible explanations for this result could be that the users are not used to using the smartphone in this manner. A prolonged experiment with several sessions may reveal whether this speculation holds or not. Another plausible explanation is the quality of the finger panning software with a relatively low refresh rate and some perceivable lag. The tracking of the finger is also challenging with varying light conditions. It is thus likely that the traditional panning method gave the users a more sense of control and response than our implementation.

A limitation of this work is that it was carried out using participants without reduced visual acuity. However, one it is unlikely that users with reduced acuity would exhibit more positive results with finger tracking.

6. CONCLUSION

A simple experiment was conducted to assess the feasibility of magnification panning by finger tracking. The results showed that traditional panning using the device was preferred by users and gave shorter task-completion-times. Other panning mechanisms should be explored to simplify panning.

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