Improving Mobile Reading Experiences While Walking Through Automatic Adaptations and Prompted Customization

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ABSTRACT

Increasingly more people are consuming information on the go, and yet walking can significantly affect the ability to read text documents on mobile devices. In this work, we propose a system that automatically detects when a user is walking while reading on mobile devices to suggest automatic adaptations and recommendations to improve reading experiences. The user can also customize these suggested adaptations in real time, which our system uses to offer future recommendations. We ran a preliminary user study to evaluate our prototype and identify challenges and opportunities of mixed-initiative adaptations for reading on the go.

CCS CONCEPTS

• **Human-centered computing** → *Interactive systems and tools.*

KEYWORDS

Mobile Readability; Situational Impairments; Personalization

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1 INTRODUCTION

Walking is one of the prevailing "situational impairments" [11, 12] that can significantly affect one's abilities to interact with applications on mobile devices [6], especially reading documents. Walking can compromise one's visual ability to view the text content [2], fine motor ability to navigate documents through touch-based gestures [1], and cognitive ability to comprehend the content while navigating the physical environment [10].

While there is an opportunity to adapt reading experiences for walking, user needs and preferences can vary, and customizing the text settings under this situation can be quite challenging. For instance, users may not have the bandwidth to adjust settings while walking, nor be motivated enough to customize at other times.

Prior work has addressed the challenges of reading while walking through various approaches, such as highlighting text at the previous gaze location to assist resumption of reading after distraction [8] and eye-reduced document skimming to facilitate non-visual document reading under situational impairments [7]. However, most prior work considers a single standardized form of adaptation for walking, allowing little space for user customization.

To bridge this gap, we propose a system that automatically detects walking during mobile reading, and provides a contextual dialog window containing a recommended adjustment to a single text parameter (e.g., font size). The user can further customize these simple settings in real time, while our system remembers these choices to improve future recommendations over time.

We ran a preliminary user study with 6 participants to evaluate our initial prototype and consider the challenges and opportunities of mixed-initiative [3] adaptations while reading on the go. We evaluated four different interventions, implemented as different mobile UI components. Our results suggest that users prefer the intervention with least text occlusion, reduced interruptions, and gestural control as an alternative to buttons and menus. We also found varying user preferences of automation versus direct manipulation, hinting at the need for personalization.

2 SYSTEM IMPLEMENTATION

User-Specific Walking Detection. Our system wraps the Apple Core Motion library [5] for walking detection. To avoid frequent, undesirable changes due to overly sensitive motion detection, our system applies a user-specific smoothing mechanism. Whenever a walking event is detected, our system starts a three-second smoothing timer and only processes this event if walking is consistently detected during this time window. Then, our system compares the real-time raw accelerometer and gyroscope sensor data with captured "benchmarks", i.e., raw sensor data of previously confirmed "walking" and "stationary" events of this user. Our system only considers an event as walking if it passes the three-second window, and is closer to the confirmed "walking" benchmark compared to "stationary" for this specific user.

Real-Time UI Interventions. When a user starts walking, our system automatically triggers UI interventions that either automatically apply the recommended adaptations or prompt the user to customize the text settings. When the system detects that the user has stopped walking, the user is first asked for confirmation, before being shown the full set of text customizations. We designed four different interventions using common mobile UI components[1]:

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[1]The pop-up window and notification build on existing iOS widgets. The bottom panel is inspired by the Kindle text setting interface and Adobe Liquid Mode [2].

[2]https://www.adobe.com/acrobat/hub/how-to/what-is-adobe-liquid-mode.html

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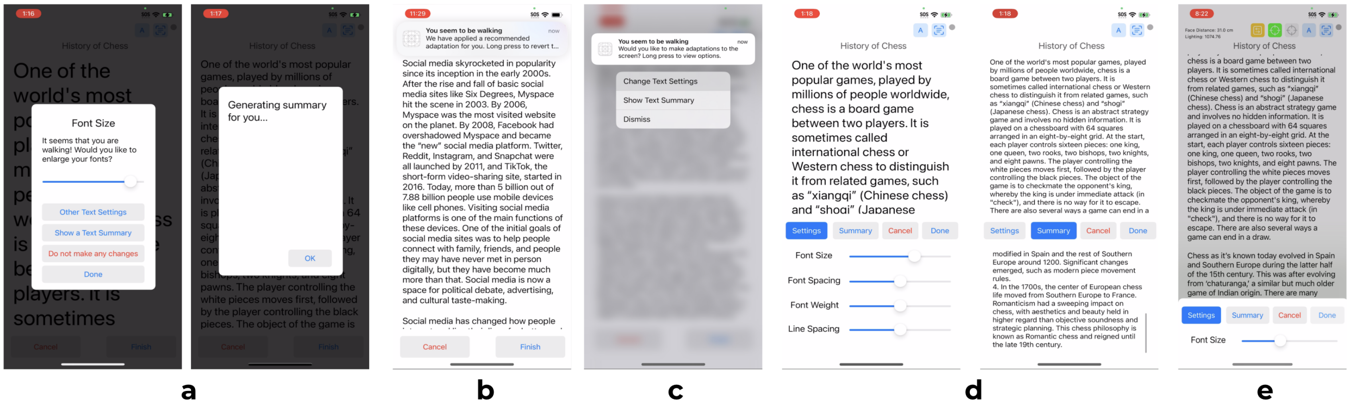

Figure 1: Interfaces supporting adaptations of reading experience when walking is detected: (a) pop-up window with a slider for a single parameter, (b) notifications with adaptations automatically applied, (c) notifications with adaptations manually applied, (d) bottom panel with the full set of parameters; (e) improved UI intervention based on preliminary user study takeaways.

(1) *Pop-up window:* A dialog window pops up and automatically applies the recommended settings, providing the user with a slider to adjust a single parameter setting (e.g., font size) or access a summary of text and additional settings (Fig. 1a).
(2) *Notifications (Automatic):* A non-obtrusive notification shows up at the top of the screen and recommended adaptations are automatically applied. A user can revert undesired adaptations or make further customization as they wish (Fig. 1b).
(3) *Notifications (Manual):* A non-obtrusive notification shows up at the top of the screen but the recommended adaptations are *not* automatically applied unless selected (Fig. 1c).
(4) *Bottom panel:* A setting panel with the full set of text parameters appears at the bottom of the screen and automatically applies the recommended adaptations (Fig. 1d).

Observing Customization Behavior. Our system records user customizations to refine future recommendations. The previous user-specified value for text settings is remembered and used as the new recommended value. As only one setting parameter is adjusted at a time, the last user-adjusted parameter will be used as the new "default" parameter to be adjusted for this specific user.

3 PRELIMINARY USER STUDY

3.1 Participants, Apparatus and Procedure

We ran a preliminary user study with 6 participants. The prototype was an iOS app running on iPhone 12. All participants were asked to start seated while reading a provided document, then to stand up and keep reading while starting walking. After completing a few paragraphs, participants were asked to again sit down and complete reading the document. All participants were presented with all four interventions, in a randomly-assigned order. Participants were asked to provide a brief summary of the documents they had read to demonstrate comprehension, and to answer a few questions regarding their experience and feedback.

3.2 Study Takeaways

Avoid frequent changes, occlusion and losing track of text. Participants found the UI adaptations and interventions more favorable if they were not overly frequent, since reading while walking already requires high cognitive load. Participants also found that font size changes sometimes made them lose track of where they were reading, an issue that can potentially be resolved with approaches like a Digital Reading Ruler [9] or SwitchBack [8].

Gestural control over target acquisition. Some participants found the buttons and tabs in the dialog windows (Fig. 1a) hard to trigger, due to the compromised touch abilities while walking [1]. Participants also found some default actions such as the notification long press (Fig. 1b) too overwhelming for walking, which calls for the need of gestural control over target acquisition for applying and reverting adaptations, navigation, and parameter adjustment.

Variation of user preference over automation and direct manipulation. While participants generally preferred adjusting one parameter at a time, participants were split over their preference for automation versus direct manipulation. Some participants mentioned that their preference of automation over direct manipulation is content-dependent. This indicates that our system should keep options open along the spectrum of mixed-initiative [3] adaptations.

3.3 System Refinements

We refined our system design and implementation based on our preliminary study findings. First, to avoid frequent interruptions, we removed the frequent system confirmation with users on their activities and preferences, and only prompt to show the full text setting upon task completion instead of every time a user stops walking. Second, we improved the UI intervention to be a small drawer window (Fig. 1e) with less occlusion of the text. Third, we implemented more sensor data collection including user eye distance from screen and lighting intensity using ARKit [4] to better inform system recommendation of text settings while walking.

4 NEXT STEPS

Our next steps are to further improve the UI interventions and implement gestural instead of button controls. We plan to incorporate interventions such as the Reading Ruler [9] or SwitchBack [8] to help with reading resumption. We will extend the recommendation mechanism that observes user customization behavior over time, and utilize additional sensor data to incorporate more situational and environmental factors. In future work, we plan to consider situational impairments other than walking.

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