Optimizing Button Size to Enhance User Experience for Augmented Reality Interactions in Mobile Scenarios

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Abstract. The anticipated widespread use of augmented reality (AR) head-mounted displays (HMDs) as daily mobile devices underscores the importance of button size, a critical factor influencing user interface effectiveness and task performance. While most mobile device interactions occur during walking, prior research on button touch has primarily been conducted in stationary VR or AR HMD environments, often neglecting the dynamic context of mobile use. This study addresses this gap by optimizing button sizes in AR user interfaces specifically for walking conditions. The objective is to identify an ideal button size that maximizes task performance accuracy while minimizing visual obstruction. Utilizing a randomized complete block design, participants interacted with buttons of various sizes (15 - 55 mm) in an AR setting. Findings indicate that larger buttons enhance task performance though excessively large buttons can cause visual obstruction and dizziness. The optimal size was identified to be 45 mm, balancing design and user experience. This research contributes to human-computer interaction in AR, emphasizing user-centered design in emerging technologies.

Keywords: Augmented Reality, Human-Computer Interaction, Button Size, User Interface Design, User Experience

1 Introduction

Virtual Reality (VR) and Augmented Reality (AR) are rapidly advancing technologies poised to impact daily life. While VR requires users to disconnect from the real world and interact within preset boundaries and computer-generated scenes, AR overlays virtual images onto the real world via head-mounted displays (HMDs), enhancing real-world experiences [1]. As AR HMD technology becomes more portable and flexible, these devices are expected to become as ubiquitous as smartphones, potentially even replacing them. Using AR HMDs as daily communication devices will require users to interact with their surroundings and virtual objects simultaneously in mobile scenarios.

The size of buttons on smartphones and extended reality (XR) devices is one of the main factors of user interface (UI) and significantly affects performance accuracy and usability. Previous research has examined the optimal button sizes for smartphones and VR [2, 3, 6], as well as factors affecting AR button-pressing tasks [4, 5]. Although mobile devices are usually used while walking, previous research on button touch was conducted mainly within stationary VR or AR HMD environments, and the interactive aspect within mobile scenarios has been often overlooked and remained underexplored. Therefore, it is essential to reevaluate the UI interaction in AR settings and assess its usability while walking in the real world, taking the surrounding environment into account. This study aims to optimize button sizes in AR user interfaces specifically for walking conditions.

2 Methods

2.1 Experimental Design

The experiment adopted a randomized complete block design (RCBD), which allowed for the assessment of button sizes (15 mm, 25 mm, 35 mm, 45 mm, and 55 mm) as five treatment levels. Sizes 15 to 45 mm were based on previous studies in static and mobile states [3, 6, 7] and we added 55 mm for walking conditions navigating the real environment. Each participant experienced all treatments in random order, with three trials. Each trial included five sessions presenting all button sizes in randomized sequences to minimize learning or fatigue effects.

For performance evaluation, task completion time, deviation range, and wrong button selections were measured. Unity tracked button presses via index fingertip coordinates. Deviation range was defined as the average Euclidean distance of attempts within 4 cm of the final successful presses [8]. Task completion time was the time from receiving the instruction in the pop-up message to finally pressing the button. For user experience, participants reported their preferences for different button sizes.

2.2 Participants

Ten right-handed adults, 5 males and 5 females (age 21 - 29, M= 23.5, SD= 2.38) were recruited. All participants had normal walking capabilities as well as normal eyesight. Participants were asked to fill in the consent form and write down some basic data.

2.3 Experimental Setting

The experiment employed a Microsoft HoloLens 2 and Leap Motion 1 as a robust hand-tracking device. The task scene and data collection system were developed using Unity 3D (2019.3.7f1) and displayed to the HoloLens via a wireless connection.

Fig. 1. AR scene with buttons of different sizes : 15, 25, 35, 45, and 55 mm at the distance of 450 mm.

Fig. 2. Participant conducting the button pressing task along with the guideline.

We designed the scene with 5 buttons displaying different icons aligned in a row at the bottom of the view to optimize participants' walking visibility (Figure 1). The order of icons was randomized for each attempt. Buttons were positioned 450 mm from the users' eyes based on adult arm length averages [9]. All buttons shared fixed center positions within their size groups to maintain consistency. Task instructions were delivered through pop-up messages above eye level to simulate realistic alerts. Pop-ups were triggered by the experimenter at random times within the Unity scene.

For the experimental environment, we drew the J-shaped guideline path with 1.5 m of curved path and 2 m of straight path on the floor to represent real-like walking conditions where participants should follow the path. Participants walked following the path while conducting the task. They were instructed to walk at their preferred pace with speed adjustments made if necessary. We asked participants to use only the index finger to collect accurate hand trajectory (Figure 2).

2.4 Experimental Procedure

First, we calibrated the positions of the virtual and real hands to match well. Participants underwent an initial familiarization with the AR environment and task. Once acclimated, they positioned themselves at the starting point of a walking path. Following the experimenter's verbal instructions, participants were tasked with pressing the correct button indicated by a pop-up prompt. Each session featured five different button sizes in random order, tested across three repetitions (15 trials total). After pressing the button, participants returned to the starting point. Following each trial, participants provided subjective ratings for their button preference. The experiment ended with an interview to gather feedback on the overall experience and UI.

2.5 Statistical Analysis

A repeated-measures analysis of variance (ANOVA) was performed to analyze the main effect of button size on task completion time and deviation range by using Python, and Minitab 21.4.2. Post-hoc analysis was conducted using the Least Significant Difference (LSD). For participants' preferences of best and worst button size and the number of wrong button selections, frequency analysis and Chi-square test were conducted.

3 Results

The results of three performance metrics (task completion time, deviation range, and number of wrong button selections) and subject preferences (most and least preferred sizes) are summarized in Figures 3 and 4. Details are described as follows.

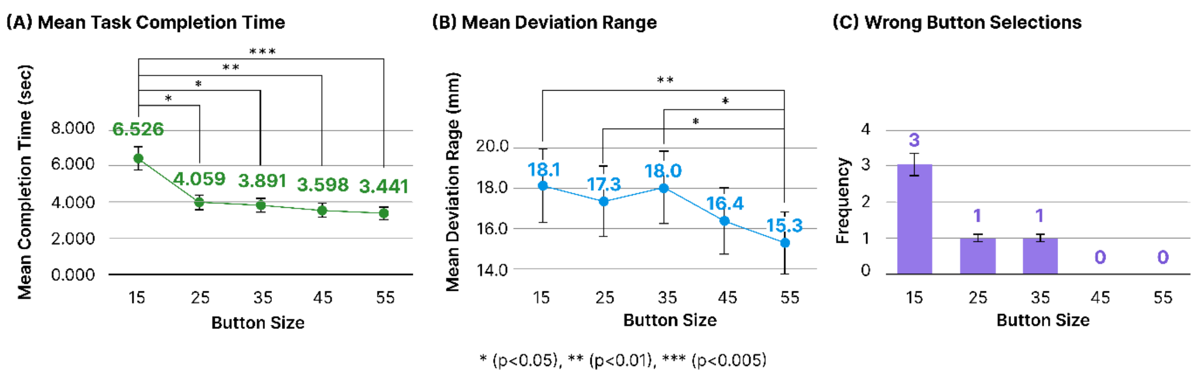

Fig. 3. Performance metrics under different button sizes (A) task completion time; (B) deviation range; (C) frequency of wrong button selections. (* significant between-group differences.)

3.1 Task Completion Time

The ANOVA test revealed a significant effect of button size on task completion time ($F(4, 36) = 3.24$, $p = .023$). The LSD post-hoc test (Figure 3 (A)) shows that the smallest button size, 15 mm was statistically significant and different from button sizes 25 mm ($p = .018$), 35 mm ($p = .012$), 45 mm ($p = .006$) and 55 mm ($p = .004$). However, no significant differences were found between other button sizes.

3.2 Deviation Range

The button size had a statistically significant impact on the deviation range ($F(4, 36) = 2.85$, $p = .038$). The LSD post-hoc test (Figure 3 (B)) indicates that 55 mm size was statistically significant and different from button sizes 15 mm ($p = .008$), 25 mm ($p = .048$), and 35 mm ($p = .010$). The largest button size (55 mm) resulted in a significantly less deviation compared to the smaller button sizes.

3.3 Wrong Button Selections

A frequency analysis of wrong button selections revealed that the smallest button size (15 mm) had the highest frequency of wrong selections as shown in Figure 3 (C). This pattern suggests that smaller buttons could potentially increase the frequency of wrong button selections in practice.

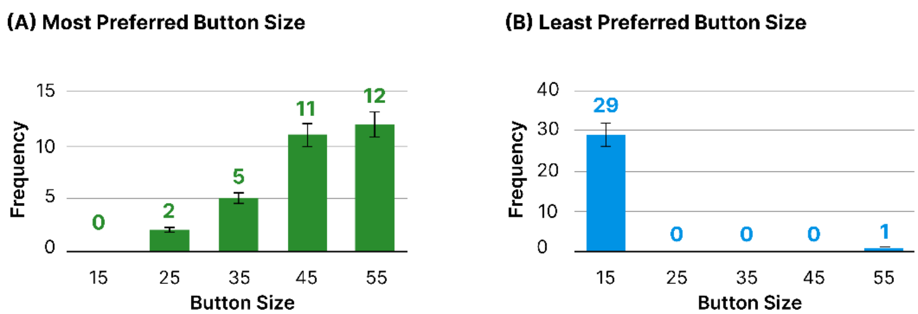

Fig. 4. Frequency distribution of (A) Most preferred button size, (B) Least preferred size.

3.4 User Preference

As shown in Figure 4, the participants exhibited a clear preference trend, favoring the larger button sizes (45 mm and 55 mm) over the smaller ones, especially the smallest one (15 mm). These preferences are consistent with the objective performance data. Chi-square analysis revealed a significant difference ($\chi 2$ $(4, 60) = 8.9$, $p < .001$) in participants' preference ratings for various button sizes. This indicates that certain button sizes are favored over others, reflecting the consistency of user preferences.

4 Discussion

This AR interface design study explored the optimization of UI button sizes to maximize task performance accuracy and enhance user experience while walking in the augmented real world. This focus is particularly relevant given the increasingly mobile usage contexts for AR technologies. Results of task completion time and deviation range indicated an inverse relationship between button size and performance metrics. Results showed that both task completion time and deviation range were significantly affected by button size, with smaller buttons leading to decreased accuracy and longer completion times. This is consistent with the concept that the smaller button size (e.g., 15 mm) may be harder to see and press with precision, leading to skewed results in user preference ratings as it was selected as the worst button in most cases.

On the other hand, the post-experiment interview revealed that the largest button size (55 mm) was too big and occasionally obstructed the user's view, causing fatigue and dizziness. Some participants also experienced dizziness when focusing on the smallest buttons, highlighting the need for future studies to consider measuring mental workload and cybersickness [5].

Prior research in static VR environments identified 20 to 25 mm as the optimal button size [3, 6], 32 mm in static AR environment [9], while the study in mobile VR found 40 mm to be ideal [7]. However, the mobile VR study [7] was conducted on treadmills, which did not require users to navigate real-world surroundings. Our experiment identified 45 mm as the optimal button size for AR interfaces, as it balanced visibility and usability without overwhelming the user's field of view or causing discomfort. This size correlated with high user preference, no wrong button selections, and good performance metrics. These findings align with interaction design principles that emphasize intuitive interactions for efficient navigation in AR settings [10].

This study contributes to the body of knowledge on AR UI design for mobile scenarios in real-world environments, offering evidence-based design recommendations. Our findings support the development of UI guidelines to prevent potential accidents caused by UIs obstructing the user's view or requiring excessive attention, which can hinder situational awareness while walking. Continuous adaptation of interface design principles is crucial for developing functional, comfortable, and immersive AR experiences.

Future research should involve a larger and more diverse participant pool to ensure more reliable conclusions and to explore various view distances, spacing, and layouts to enhance generalization. This user-centered approach is essential for designing AR interactions that accommodate the diverse conditions of mobile usage.

5 Conclusion

This study explored the optimal button size that maximizes task performance accuracy while minimizing visual obstruction during mobile walking interactions in AR. The results showed that a button size of 45 mm in AR interfaces was optimal, striking a balance between design and user experience, ensuring accurate interaction without overwhelming the user's view or causing discomfort. These findings underscore the importance of user-centered design in AR technology, offering evidence-based design recommendations and valuable insights for future AR interface development.

Acknowledgments

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