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Exploring Gaze-Based Menu Navigation in Virtual Environments

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ABSTRACT

With the integration of eye tracking technologies in Augmented Reality (AR) and Virtual Reality (VR) headsets, gaze-based interactions have opened up new possibilities for user interface design, including menu navigation. Prior research in gaze-based menu navigation in VR has predominantly focused on pie menus, yet recent studies indicate a user preference for list layouts. However, the comparison of gaze-based interactions on list menus is lacking in the literature. This work aims to fill this gap by exploring the viability of list menus for multi-level gaze-based menu navigation in VR and evaluating the efficiency of various gaze-based interactions, such as dwelling and border-crossing, against traditional controller navigation and multi-modal interaction using gaze and button press.

CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; **Interaction techniques**.

KEYWORDS

Extended Reality (XR), Gaze-based Interaction, Menu Navigation, Eye Tracking

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1 INTRODUCTION

The integration of eye trackers into major Augmented Reality (AR) and Virtual Reality (VR) headsets has made gaze-based menu manipulation feasible for everyday tasks. Despite the availability of open standards that facilitate development across different headsets, the field lacks a uniform design framework for user interfaces, resulting in diverse and non-standardized menu systems. While several menu layouts have been proposed, the pie menu is the most researched layout for gaze-based interaction [1, 4, 8]. However, comparative studies by Monteiro et al. [6] and Lediaeva and LaViola [5] indicate that users prefer list layouts over pie layouts. Furthermore, Lediaeva and LaViola [5] found that for single-level menu selection with gaze interaction, there was no significant difference in task completion time between pie and list layouts.

Mutasim et al. [7] conducted a comparative analysis of pie menus, examining various gaze-based interaction mechanisms such as dwelling, border-crossing, and gaze and button press for selection. The study showed that border-crossing was significantly faster than gaze and button press or dwell interactions, while dwell had the lowest error rate. However, the literature lacks a comparison of gaze interactions on list menus and a comparison of list and pie menus for border-crossing.

This work in progress investigates whether list menus could serve as a viable alternative to pie menus for gaze-based multi-level menu navigation in AR/VR. It also examines whether gaze-based interactions, such as dwell, border-crossing, or gaze and button press, can provide a more efficient navigation mode compared to controllers. Given the absence of a multi-level list menu design for the border-crossing method, we adapted the list menu layout from [6], incorporating recommendations from [4] for pie menus to support border-crossing.

To evaluate the resulting menu design, we will conduct a two-way within-subject study. This study will measure objective metrics, such as task completion time and error rate, and subjective metrics using the System Usability Scale (SUS) [2] and responses to a post-experience questionnaire, to gain a comprehensive understanding of user interaction and satisfaction.

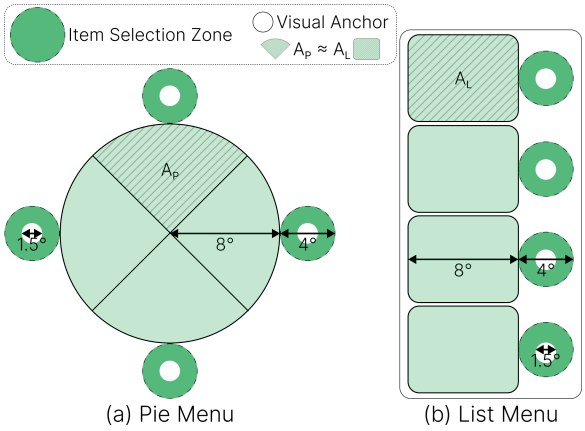

Figure 1: Design of (a) pie and (b) list menu, with angles represented in visual degrees.

2 MENU DESIGN

We implemented two distinct menu layouts: a pie menu and a list menu. The pie menu is based on the lattice menu by Kim et al. [4], featuring a circular arrangement that allows users to select menu options by directing their gaze at visual anchors positioned equidistantly around a central point. The list menu design is adapted from Monteiro et al. [6], incorporating visual anchors within menu options with subsequent levels extending to the right.

Following the suggestions of [4], both menu layouts are designed with a horizontal visual angle of 8° for menu items and an additional 4° for the item selection zone, which includes a visual anchor with a radius of 1.5°. Figure 1 illustrates these layouts, highlighting the item selection zones and visual anchors.

To facilitate seamless menu navigation and accommodate various interaction types, we incorporated visual feedback into the design. When a user hovers their gaze or controller over a menu option, the option is highlighted, indicating readiness for selection.

We investigate the following interaction mechanisms:

- **Dwell:** Users activate menu options by maintaining their gaze within the item selection zone for 300 ms [7]. This technique serves as a baseline for gaze-based interaction.
- **Border-crossing:** Menu options activate immediately when users direct their gaze into the item selection zone.
- **Controller:** Users activate menu options by aiming their controller within the entire region of the menu option and pressing a button. This interaction serves as a baseline for traditional controller navigation.
- **Gaze and button press:** This multi-modal approach combines gaze as a pointing mechanism with button presses for confirmation, addressing the Midas Touch Problem [3] and eliminating the need for dedicated item selection zones.

3 USER STUDY

We validate the usability and efficiency of gaze-based menu navigation through a user study comparing entry times, usability, and error rates of multi-level list and pie menus. Following Kim et al. [4], the menu designs are validated using world-referenced placement, where menus are positioned at fixed coordinates in the AR/VR world, and head-combined gaze input is used for navigation. Participants are given five random three-letter strings representing menu sequences to enter for each condition, with each sequence repeated four times to assess the learning curve. A preliminary study will be conducted to finalize the menu designs and refine the study setup.

The study will be conducted with 20 participants using the HTC Vive XR Elite headset[1]. It employs a two-way within-subjects design, comparing two menu layouts and four interaction mechanisms, resulting in a total of 8 conditions. The order of the *Layout* × *Interaction* conditions are counterbalanced using a Balanced Latin Square. Before each condition, the eye tracker is recalibrated, and its accuracy and precision is measured. After each round, participants complete a SUS questionnaire, and brief breaks are provided to prevent fatigue. At the end of the study, a post-experiment questionnaire is used to gather user feedback on their experience and preferences.

4 CONCLUSION

This work aims to explore the effectiveness of gaze-based menu navigation using list and pie menus in VR environments. By comparing different interaction mechanisms such as dwell, border-crossing, controller, and gaze and button press, we seek to identify the most efficient and user-friendly approaches to menu navigation in VR. The results from our planned user study will provide insights into user preferences and performance across various conditions. We anticipate that this research will contribute to the development of more intuitive and efficient gaze-based interaction designs, enhancing the user experience in AR and VR applications.

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