Sun Menu: An Outward Ray-Based Radial Menu for Accurate VR Selection

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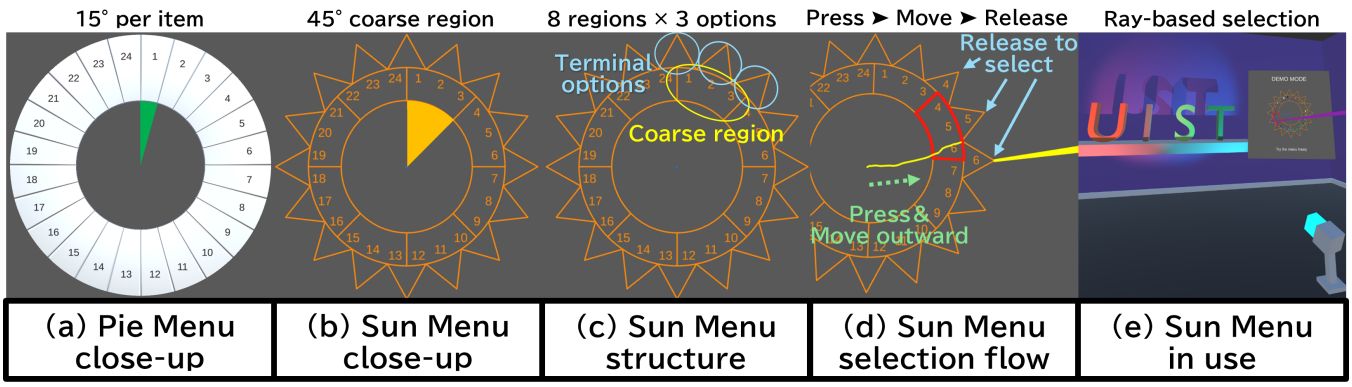


Figure 1: Overview of Sun Menu and the baseline Pie Menu. (a) Pie Menu directly divides 24 items into equal angular sectors, resulting in 15° per item. (b) Sun Menu provides a wider 45° coarse region for initial direction selection. (c) Sun Menu consists of 8 coarse regions, each connected to 3 terminal options. (d) The selection procedure consists of pressing the trigger, moving the ray outward, and releasing the trigger to confirm the selection. (e) A possible application scenario shows Sun Menu being used to select one of 24 colors for coloring a 3D object in a VR interface.

Abstract

In dense VR radial menus such as Pie Menus, each item's angular width shrinks as item count grows, making selection errors likely during rapid ray-based selection. We propose Sun Menu, which arranges 24 items into eight coarse regions, each connected to three terminal options on the outer edge. Sun Menu accepts the initial ray direction as a coarse directional selection and defers fine-grained candidate selection to the outer terminals, so that users need not aim directly at narrow angular sectors while selection remains a single outward ray movement. In a user study with a 24-item Pie Menu as a baseline, Sun Menu showed significantly lower error rates under all of the Accurate, Neutral, and Fast instruction conditions, and no significant increase in selection time was observed. These results suggest that Sun Menu reduces selection errors in dense VR radial menus without a significant increase in selection time.

CCS Concepts

• **Human-centered computing** → **Interaction techniques**; *Pointing*; *Virtual reality*.

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Keywords

Virtual reality, Ray-based selection, Radial menus, Selection accuracy, Sun Menu

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1 Introduction

Menu selection in VR requires users to quickly and accurately select a target function from a large set of items. Radial menus, exemplified by Pie Menus and marking menus, support fast selection through directional movements from the menu center toward the periphery [3, 6, 7]. Recent studies of VR menus have further identified the number of menu items, the input method, selection time, and accuracy as key dimensions for evaluating menu techniques [9].

However, in radial menus, the angular width allocated to each item decreases as the number of items grows. In VR raycasting in particular, small hand and tracking jitter destabilizes control of the ray direction, and small hand movements are amplified at the tip of a long ray [1, 5]. Consequently, when the angular width per item is limited to 15°, as in a 24-item Pie Menu, ray-based selection becomes prone to errors on adjacent items.

For large item sets, prior techniques such as hierarchical marking menus and Flower menus employ multi-stage selection or curved

gestures [2, 10]. While these techniques accommodate more commands with a limited number of directions, they may require users to repeatedly decide, at each hierarchy transition or along a curved trajectory, in which direction to move the ray next. Moreover, studies of handwriting and drawing movements report a kinematic regularity that movement speed decreases as trajectory curvature increases [8]; sharply curved movements may therefore weaken the fast directional selection that radial menus originally afford.

In VR, the Bump Pie Menu reduces selection errors by adding protrusions along the outer edge of a Pie Menu so that the ray can catch on them, guiding ray movement [4]. Such work demonstrates that peripheral structures can effectively support ray operations in multi-item VR menus.

Building on peripheral support for ray operations, we propose Sun Menu. Instead of dividing 24 items into narrow angular sectors from the outset, Sun Menu accepts the initial movement with a wide angular tolerance and separates candidates at the end of the outward movement. Sun Menu arranges 24 items into eight 45° coarse regions, each with three outer terminal options (Figure 1). Rather than requiring users to aim at 15° sectors from the start, this design lets them complete both coarse directional selection and final candidate confirmation within a single movement toward visible terminal options on the periphery, without additional decisions at hierarchy transitions or large changes of direction. Our contribution is to show that, for a dense 24-item radial VR menu, a design that accepts a coarse initial direction and separates candidates at the periphery can reduce selection errors without a significant increase in selection time.

2 Sun Menu

Sun Menu is a radial menu presented on a plane in VR space. The user wears an HMD and points at the menu with a ray extending from the right-hand controller. A selection is made by pressing the trigger to begin the ray operation, moving the ray outward, and releasing the trigger to confirm the item (Figure 1(d)).

As shown in Figure 1(b)(c), Sun Menu arranges 24 items into eight coarse regions and three terminal options attached to the outer edge of each region. Whereas a Pie Menu divides 24 items into 15° sectors, Sun Menu accepts the initial movement direction as a 45° coarse region. Users therefore do not need to precisely aim at one of 24 densely packed items immediately after starting the operation; instead, they first move the ray in a rough direction and then choose among the three candidates at the terminal part attached to that region.

The central feature of Sun Menu is that it integrates coarse directional selection and fine-grained terminal selection into a single outward movement from the menu center, without requiring users to explicitly switch between stages. This design aims to reduce selection errors on dense item sets without demanding fine angular adjustment or sharply curved trajectories, keeping the entire selection a single ray operation toward visible peripheral candidates.

Thus, Sun Menu supports selection from dense item sets by combining coarse directional selection with fine-grained candidate selection at the periphery. For example, it can support repeated selection from dense candidate sets, such as frequently switching among 24 colors when coloring a 3D object in VR (Figure 1(e)).

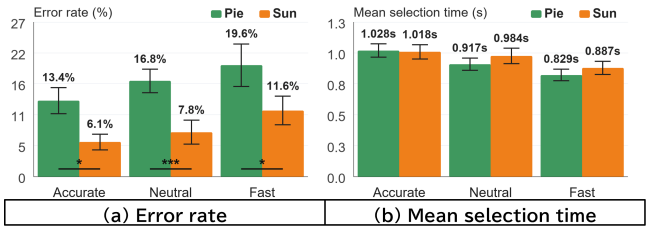


Figure 2: Error rate and mean selection time for Pie Menu and Sun Menu across three instruction conditions. (a) Error rate was computed from all trials. (b) Mean selection time was computed from correct trials. Error bars indicate standard error. Asterisks in panel (a) indicate significant pairwise differences between Pie Menu and Sun Menu within each instruction condition after Bonferroni correction ($^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$).

3 User Study

To evaluate Sun Menu, we conducted a user study with a VR system implemented in Unity. Twelve participants took part in the study (ages 20–23, $M = 21.8$, $SD = 0.9$; 9 male, 3 female). As a baseline, we used a Pie Menu with 24 items arranged in equal angular sectors. The two menus were compared under identical display distance, display scale, input method, feedback, and task procedure.

The study followed a 2 (menu type: Pie Menu, Sun Menu) × 3 (instruction condition: Accurate, Neutral, Fast) within-subjects design. Participants selected the item corresponding to a displayed target number with the ray. In each condition, target numbers from 1 to 24 were presented in random order; participants pressed the trigger to begin the ray operation and released it to confirm the selection. Each participant completed three repetitions of 24 trials for each menu type and instruction condition combination; the first repetition was treated as practice, and only the latter two repetitions were analyzed. The order of menu types and instruction conditions was counterbalanced across participants.

The dependent variables were selection time and selection error rate. Selection time was the interval from target presentation to trigger release in correct trials. Error rate was computed as the proportion of all trials in which the selected item did not match the presented target. For each measure, we conducted a two-way repeated-measures ANOVA with menu type and instruction condition as within-subjects factors, applying sphericity corrections where necessary. Bonferroni correction was applied.

Figure 2 shows (a) error rates and (b) mean selection times for each condition. For error rate, the main effect of menu type was significant, with Sun Menu showing a lower error rate than Pie Menu, $F(1, 11) = 21.75$, $p < .001$, $\eta_p^2 = .664$. The main effect of instruction condition was also significant, $F(2, 22) = 3.71$, $p = .041$, $\eta_p^2 = .252$, whereas the interaction between menu type and instruction condition was not significant. Pairwise comparisons showed that Sun Menu had significantly lower error rates than Pie Menu in all of the Accurate, Neutral, and Fast conditions. For selection time, the main effect of instruction condition was significant, with selection times decreasing from Accurate to Neutral to Fast, $F(1.34, 14.69) = 19.39$,

$p < .001$, $\eta_p^2 = .638$. Neither the main effect of menu type nor the interaction was significant.

These results suggest that Sun Menu reduced selection errors in a dense 24-item VR menu—even under the Fast instruction—while no significant increase in selection time was observed. Accepting a 45° coarse initial direction and separating candidates at the outer terminals may have mitigated small directional deviations caused by hand jitter during rapid ray operations. Sun Menu thus suggests a design direction for dense VR menus: supporting accurate selection by combining coarse directional selection and terminal selection within a single outward ray movement, rather than relying only on finer angular subdivision.

In free-form comments, participants attributed errors in Pie Menu to hand jitter and drift at trigger release, and described Sun Menu as easy to select accurately but hard to recover from once an unintended coarse region was entered. A limitation of this study is that we did not collect structured usability or preference measures; the qualitative observations reported here are limited to free-form comments. In future work, we will analyze ray trajectories on the menu plane to examine Sun Menu from the perspective of error recovery, including correction before confirmation and reselection after an error.

References

[1] Ferran Argelaguet and Carlos Andujar. 2013. A Survey of 3D Object Selection Techniques for Virtual Environments. *Computers & Graphics* 37, 3 (2013), 121–136. doi:10.1016/j.cag.2012.12.003

[2] Gilles Bailly, Eric Lecolinet, and Laurence Nigay. 2008. Flower Menus: A New Type of Marking Menu with Large Menu Breadth, Within Groups and Efficient Expert Mode Memorization. In *Proceedings of the Working Conference on Advanced Visual Interfaces* (Napoli, Italy) *(AVI '08)*. Association for Computing Machinery, New York, NY, USA, 15–22. doi:10.1145/1385569.1385575

[3] J. Callahan, D. Hopkins, M. Weiser, and B. Shneiderman. 1988. An Empirical Comparison of Pie vs. Linear Menus. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Washington, D.C., USA) *(CHI '88)*. Association for Computing Machinery, New York, NY, USA, 95–100. doi:10.1145/57167.57182

[4] Nobuhito Kasahara and Homei Miyashita. 2023. Bump Pie Menu: A Circular Menu for Selecting Targets by "Hooking" Rays in VR Environments. In *Proceedings of the 31st Workshop on Interactive Systems and Software (WISS 2023)*. 1–3. In Japanese; English title is a translation of the original Japanese title. https://www.wiss.org/WISS2023Proceedings/data/1-B04.pdf

[5] Regis Kopper, Felipe Bacim, and Doug A. Bowman. 2011. Rapid and Accurate 3D Selection by Progressive Refinement. In *2011 IEEE Symposium on 3D User Interfaces (3DUI)*. 67–74. doi:10.1109/3DUI.2011.5759219

[6] Gordon Kurtenbach and William Buxton. 1993. The Limits of Expert Performance Using Hierarchic Marking Menus. In *Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems* (Amsterdam, The Netherlands) *(CHI '93)*. Association for Computing Machinery, New York, NY, USA, 482–487. doi:10.1145/169059.169426

[7] Gordon Kurtenbach and William Buxton. 1994. User Learning and Performance with Marking Menus. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Boston, Massachusetts, USA) *(CHI '94)*. Association for Computing Machinery, New York, NY, USA, 258–264. doi:10.1145/191666.191759

[8] Francesco Lacquaniti, Carlo Terzuolo, and Paolo Viviani. 1983. The Law Relating the Kinematic and Figural Aspects of Drawing Movements. *Acta Psychologica* 54, 1–3 (1983), 115–130. doi:10.1016/0001-6918(83)90027-6

[9] Johann Wentzel, Matthew Lakier, Jeremy Hartmann, Falah Shazib, Géry Casiez, and Daniel Vogel. 2025. A Comparison of Virtual Reality Menu Archetypes: Raycasting, Direct Input, and Marking Menus. *IEEE Transactions on Visualization and Computer Graphics* 31, 9 (2025), 4868–4882. doi:10.1109/TVCG.2024.3420236

[10] Shengdong Zhao and Ravin Balakrishnan. 2004. Simple vs. Compound Mark Hierarchical Marking Menus. In *Proceedings of the 17th Annual ACM Symposium on User Interface Software and Technology* (Santa Fe, NM, USA) *(UIST '04)*. Association for Computing Machinery, New York, NY, USA, 33–42. doi:10.1145/1029632.1029639