Poster: Evaluation of Menu Techniques Using a 3D Game Input Device

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ABSTRACT

With the rise in popularity of 3D spatial interaction in console gaming, such as the Nintendo Wii, it is important to determine whether existing menuing technique findings still hold true when using a 3D pointing device such as the Wii Controller. Linear menus were compared with two other menu techniques: radial menus and rotary menus. Effectiveness was measured through task completion time and the number of task errors. A subjective measure was also taken to determine participant preferences. Participants performed faster and made fewer errors when using the radial menu technique. Radial menus were also preferred by participants. These results indicate that radial menus are an effective menu technique when used with a 3D pointing device. This is consistent with previous work regarding radial menus and indicates that the usage of radial menus in gaming applications should be investigated further.

KEYWORDS: 3D Interaction, input devices, usability, user studies

INDEX TERMS: I.6.3 [Simulation, Modeling, and Visualization]: Applications, H.5.2 [Information Interfaces and Representation]: User Interfaces

1 INTRODUCTION

Traditionally, in-game tasks are performed with a linear menu. The large number of items that can be placed into a linear menu has lead to the use of icons and keyboard shortcuts to facilitate faster item selection. However, these approaches still have limitations. According to [8], while icons are easier to recognize than text, a cognitive load is still imposed when the number of icons displayed at once becomes too high.

The desire is for a menu technique that has limited impact on player task performance and allows for shortcuts to evolve based on muscle memory. Gesture based menus, such as radial menus (also known as pie [1] or marking [4] menus), may meet these requirements. The Nintendo Wii Controller contains motion-sensing elements, which we believe can be utilized to more quickly and accurately navigate a menu based on muscle memory.

In order to determine if existing gesture menu findings can be applied to the Wii Controller, we conducted a comparison study between linear and gesture based menu techniques using the Wii Controller.

2 MENU IMPLEMENTATION

Radial menus and a modified version of the rapMenu [6], called a rotary menu, were selected as the gesture menu techniques. A traditional linear menu was also included. In order to evaluate possible effects of sub-menus on performance, each technique had a layout with and a layout without submenus, for a total of 6 techniques.

Under the linear menu technique, the menu was continuously visible. Menu items were laid out in a horizontal row at the bottom of the display, consistent with many game interfaces. Radial and rotary menus are invoked with a button press. Menu items were laid out in a ring centered about the location of the cursor when the menu was invoked. If a submenu was selected, the new menu opened at the same location as its parent. Otherwise, the chosen option was executed and the menu is closed.

Linear and radial menu item selection utilized a point and click approach. With rotary menus, item selection was performed by rotating the Wii Controller about its central axis as if turning a dial.

3 EXPERIMENTAL DESIGN

A within-subjects six-way comparative study was designed to determine whether existing findings regarding linear and radial menu techniques [1] applied to 3D input devices. Performance was measured through task completion time and the number of selection errors. These measures were based on the existing findings of [1].

3.1 Participants

Twenty participants were recruited from the university population and received $10 USD. Ages ranged from 18 to 31 (Mean age 22). Each participant interacted with all six menu techniques.

3.2 Apparatus

Images were displayed on a 50" Samsung DLP 3D HDTV at a resolution of 1920 x 1080 and refresh rate of 60 Hz. A dual-core desktop PC with an nVidia GeForce 8500 graphics card was used. Experiment software was written in C# and used Microsoft's XNA game library. Participants interacted with menus and the environment with a Nintendo Wii Controller. The Bespoke 3DUI framework [7] was used to process Wii Controller input.

3.3 Environment and Task Design

Participants were provided 90 seconds of practice with each of the menu techniques in a training environment that consisted of a solid, light blue background. The menu items available were nine distinct, solid colors. When sub-menus were used, the colors were sorted into three groups of three related colors. Selection instructions were displayed via a text prompt in the upper left of the screen.

The experiment environment was an exterior, lightly forested location. The participant was tasked to uncover a pottery artifact embedded in a boulder. Eight tools used in archaeological excavation were displayed in the menus. When sub-menus were used, icons were sorted appropriately based on tool precision. Selection instructions were displayed on-screen in the upper left corner. After selecting a tool from the menu, the participant clicked on the artifact to apply the selection. A portion of the boulder was then removed and new selection instructions were displayed. The participant had as many attempts as needed to find

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and select the correct tool. After five correct applications, the scene was reset and a new trial task began.

3.4 Procedure

After a brief demographic questionnaire, participants entered a training phase. A 90-second training session with each menu technique was provided, along with written instructions on the technique. A one-minute break was provided between training and experiment phases. The experiment phase consisted of 20 task trials with each menu configuration. Menu interaction order was counterbalanced based on a 6x6 Latin Square [2]. A task trial consisted of making five successful selection attempts. After each task trial, a two-second break was given. After the 10^{th} trial, a 15-second break was provided. Between each menu type, a one-minute break occurred where menu instructions were again provided. Qualitative ratings (7-point Likert scale) and rankings (1 to 3) regarding preference and frustration were collected after menu interaction.

4 Results

Two participants' data was discarded from the analysis. One was due to a computer error and the other was due to red/green colorblindness affecting his ability to see the selected menu item.

A repeated measures one way ANOVA was performed on the completion time and error rate data to determine if menu type had a significant effect. Menu type was found have a significant effect on completion time ($F_{5, 17} = 24.404$, $p < 0.05$) and error rate ($F_{5, 17} = 18.339$, $p < 0.05$).

A post-hoc analysis with six pairwise comparisons was conducted to explore how performance varied due to menu technique. To control for the chance of Type I errors, a Holm's sequential Bonferroni adjustment [3] with 6 comparisons at $\alpha = 0.05$ was used.

4.1 Completion Time Analysis

The results for menus without sub-menus are presented first. Radial menus were significantly faster than linear menus ($t_{17} = 3.208$, $p < 0.0125$) and rotary menus ($t_{17} = -8.014$, $p < 0.01$). Linear menus were significantly faster than rotary menus, $t_{17} = -3.76$, $p < 0.008$. These results suggest that radial menus result in the fastest task completion time.

No significance was found between menu techniques when sub-menus were utilized. This indicates that increasing menu depth removes any menu technique advantage.

4.2 Error Rate Analysis

The results for menus without sub-menus are presented first. Significantly fewer errors were made with radial menus versus rotary menus ($t_{17} = -6.015$, $p < 0.008$) and linear menus versus rotary menu means ($t_{17} = -4.260$, $p < 0.01$). The difference between radial menus and linear menus was close to significant ($t_{17} = 2.350$, $p = 0.025$). These results suggest that radial menus lead to decreased error rates for participants.

For menus with sub-menus, no significance was found between radial menus and linear menus. However, significance was found when comparing rotary menus against linear menus ($t_{17} = -3.160$, $p < 0.017$) and radial menus ($t_{17} = -3.467$, $p < 0.0125$). These results indicate that increased menu depth leads to more errors when using rotary menus.

4.3 Questionnaire Analysis

Participants were asked to rate their preference and frustration of the three menu techniques on a scale from 1 (lowest) to 7 (highest). No differentiation was made between menus with sub-menus and menus without sub-menus in the questionnaire.

Rating data was analyzed with the Friedman related samples test. Preference and frustration rating differences were found to be significant ($\chi^2_{2, 18} = 16.2$, $p < 0.05$ and $\chi^2_{2, 18} = 12.09$, $p < 0.05$, respectively). A Wilcoxon Signed Rank test was then applied. To control for the chance of Type I errors, a Holm's sequential Bonferroni adjustment [3] with 3 comparisons at $\alpha = 0.05$ was performed.

Radial menus were significantly preferred to linear menus ($Z = -3.257$, $p < 0.017$) and rotary menus ($Z = -2.909$, $p < 0.025$). There was no significance preference between linear and rotary menus. These results indicate that radial menus are the preferred menu technique.

Radial menus were significantly less frustrating than linear menus ($Z = -2.425$, $p < 0.025$) and rotary menus ($Z = -3.043$, $p < 0.017$). There was no significance in frustration between linear and rotary menus. These results show radial menus to be the least frustrating menu type.

Preference rankings were analyzed through three single variable chi-square tests. An even distribution was found to not be correct for rank "1" ($\chi^2_{2, 18} = 13$, $p < 0.05$) and rank "3" ($\chi^2_{2, 18} = 12$, $p < 0.05$). Thus, menu technique had an effect on the highest and lowest rankings.

Frustration rankings were analyzed similarly. All three tests show that an even distribution was incorrect, and frustration was dependent on menu type. For rank "1", $\chi^2_{2, 18} = 10.33$, $p < 0.05$, for rank "2", $\chi^2_{2, 18} = 6.33$, $p < 0.05$, and for rank "3", $\chi^2_{2, 18} = 12.33$, $p < 0.05$.

5 Conclusions and Future Work

There are potential improvements we would like to investigate. In particular, we would like to examine an iteration of the rotary menu utilizing the Nintendo Wii Nunchuk. Alternative scaling approaches, such as found in [5], can also be used to allow for more comfortable wrist rotation, resulting in easier selections. Additionally, visual and aural feedback in the menus could be improved to facilitate better accuracy.

While we have demonstrated that the use of the Nintendo Wii Controller is consistent with existing literature on radial menus, it remains to be determined how gameplay is affected in terms of both performance and immersion. Our intention is to perform further comparison of radial and rotary menus in a game setting.

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