CSE 566 Virtual Reality, Spring 2020, Individual Final Project: **Where to display? How Interface Position Affects Comfort and Task Switching Time on Glanceable Interfaces**

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1 Session Summary

Visual rendering specifies what the visual display should show through an interface to the virtual world generator (VWG) [1].

The first paper presented a simple yet effective technique for further reducing the cost of foveated rendering by leveraging ocular dominance. Next, researchers from Germany presented a hybrid rendering system that combines classic rasterization and real-time ray-tracing to accelerate stereoscopic rendering. Then, the third paper compared two methods for characterizing the angular dependence of the spatial resolution in virtual reality head-mounted displays (HMDs) by measuring the line spread response (LSR) across the field of view (FOV) of the device. Following this, researchers proposed a multi-scale simulation method under particle-based framework to achieve the realistic and efficient simulation of air-liquid fluid, and improve the fidelity and richness of the fluid simulation [2].

Last, researchers from Virginia Tech designed a scenario to evaluate the effect of information positions in switching time and comfort on glanceable interfaces, considering both cognitive and physiological constraints, which will be later discussed in details.

2 Summary of the paper

In this paper, the author describes the effect of interface position in task switching time and comfort on glanceable interfaces. Their study investigates how three factors (horizontal angle, vertical angle and distance from the user) make effects on task completion time that spans between two interfaces.

2.1 Introduction

Contextual display is a common way to help users get assistance in different tasks. While long and complex information needs to be visible constantly during the task, in some cases people want to access the information only when they need it. As the technology progress towards all-day wearable display, these scenarios are reasonably expected to be common.

How to minimize the overhead of context switching is hence one of the main problems when designing information displays, as they are always caused by context switching between an ongoing real-world task and the AR content. Glanceable devices, which can provide a little bit information so that people can get acquisition just at a glance [4], could be a solution for this. In addition to the advantage of not blocking the center of visual field, they can efficiently help people maintain focus on the primary tasks while acquiring the information in an appropriate time [5].

However, even for the simple tasks, the alternating still needs several steps, including rotating the head and eyes, adjusting eyes vergence and accommodation, and shifting the focus of attention. Considering all of them highly depends on the where is content is rendered, the position of interface then becomes a critical choice when designing information displays in augmented reality.

2.2 Previous work

There are many researches about the mechanism of context switching in visual physiology and cognitive process. Though in most of them, the background task is still running when the interruption occurs [7]. As for the layout of virtual information, most previous works have focused on the preference of information position that are close to each other. In this paper, the authors designed tasks that are completely interrupted when the switch occurs, and then looked into the effect of distance from the user.

2.3 Experimental Design

The author created a scenario that mimics context switching between a real world-task and an information display, measuring the button response time for each input. The study investigates the effect of horizontal angle, vertical angle, and distance of the glanceable interfaces.

For this experiment the authors asked participants to perform those tasks in VR using two interfaces. The first interface emulates a primary task (e.g. watching TV), while the second emulates a glanceable AR interface that can be summoned on demand. Participants were told where the glanceable interface was before interacting with it.

When the trial begins, participants see a set of symbols on the television screen. One of the symbols is highlighted with a white square. Once participants have memorized the highlighted symbol, they can press a button on the controller to switch to the glanceable

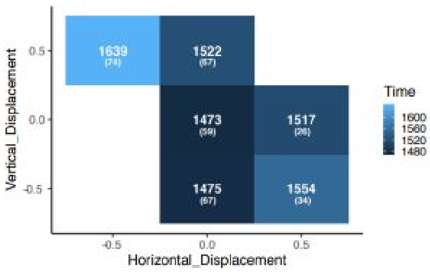

Fig 1. Mean times for different vertical and horizontal angles

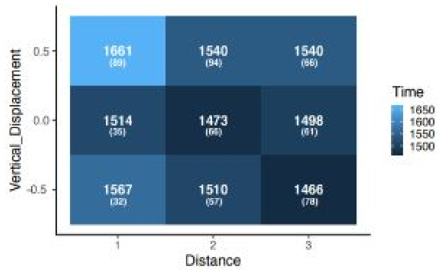

Fig 2. Mean times for different elevations and distances

Fig 3. Mean times for different horizontal angles and distances

interface. The glanceable interface will appear within the room, and show them two rows of symbols. Their task is to find the symbol they memorized on the top row and find the corresponding symbol below it. Once the participants have memorized both symbols in order, they press a button on the controller to switch back to the television screen. Back on the TV, the symbols reappear and allow the participants to select the two memorized symbols in sequence.

Participante repeated the task 12 time for each position, and completed 18 sets of this task, positioned at different angles and distance from them. In total, they completed 216 tasks, taking a 2 minutes break every 6 sets.

2.4 Result

As dependent variable, the authors measure the time between the moment the user switched to the glanceable interface and the moment the task was resumed.

For the raw data distribution in correct trials, the median time spent switching tasks was 1.44s. Along the fronto- parallel plane, participants were slower when using the interface on top left position, while faster at further up and down positions (Figure 1). From side projection, lower and further positions are faster. The higher positions closer to the user were the slowest (Figure 2). From the top projection, center positions closer to the TV were faster (Figure 3). Overall, the faster interface positions were those that were centered and below the task position.

A mixed model fitted to the time data was then conducted to show more statistical power (Table 1). With a generalized multiple regression model, the positive coefficients for angles indicates that the switching time was longer in further positions, while the smallest coefficients of distance indicated small improvements in the switching time. In general, the results showed that participants were faster when the interface was place closer to the TV.

As for the preference, All the participants were asked to give feedback through a verbal questionnaire. In general, participants preferred lower center positions with a medium distance. According to their responses, a lower angle is more familiar with them due to the habits of using cell phones. In addition, the center positions had less conflicts with the environment, while a further distance helped them to adjust visually (Figure 4).

3 CRITIQUE OF THIS PAPER

This paper investigated interface positions on glanceable devices, which has the potential to be applied in wearable devices, hense is a valuable topic to explore.

3.1 Pros and cons

There are a few advantages that contribute to the model and results. First of all, for experiment design, the authors made adjustments to the screens so that some key factors would maintain the apparent size from the participant perspective. Considering different perspectives could make symbols smaller with distance, the adjustments can contribute to avoid confounding effects on attention orientation, head movement and eye movement. Also this has the benefit of

Another advantage is about the design of experiment content. This memorizing and checking task can assure that participant actually acquire the information from the display area, which is a simple but efficient way to exclude some potential effects that could be brought by previous knowledge and lead to a more powerful result.

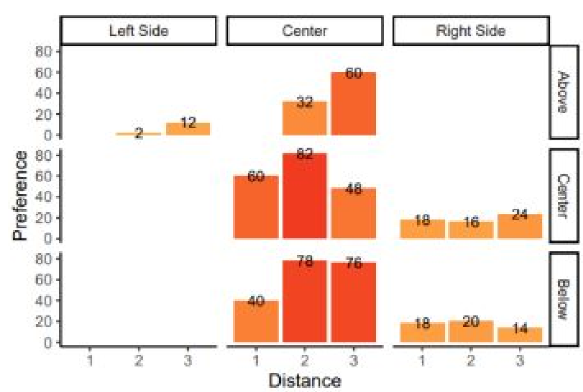

Fig4. Weighted preferences of position

However, there still exist some limitations. First, eye gaze was not recorded in this experiment. Taking this factor into consideration could help to further explore user strategies on how much to rotate their head or eyes, and may lead to a more accurate relation between the physical position and physiological visual system.

Table 1. Fixed Effects for mixed model

H Angle	std.error	conf.low	conf.high	p value
0.1537	0.0296	0.0956	0.2115	2.076e-07
V Angle	std.error	conf.low	conf.high	p value
0.0766	0.0176	0.0420	0.1112	1.442e-05
Distance	std.error	conf.low	conf.high	p value
-0.0218	0.0049	-0.0313	-0.0122	7.998e-06

Second, in this experiment, VR was used instead of AR to place more content, as current AR technology has its limitations on field of view (FOV). Although this Mixed Reality Simulation can provide a larger view while simulate a future AR headset, this is not the best solution after all [8,9,10]. The difference between focal distances could change the result of preferable positions and the comfort feedback, and may arise new problems as well.

Last, the fixed display positions led to fixed range of rotation angles along horizontal and vertical axis in this experiment. But the comfortable range for rotating eyes could be different along vertical and horizontal axises. We can expect an extended and different range would affect the positions and preference, and therefore arise new problems for the adaptability of AR devices.

3.2 The relationship between the paper and the topics covered by CSE 566

The topic of this paper is mostly related to the human visual system and perceptual psychology of depth.

For visual physiology, the mainly covered concept in this paper is accommodation. In order to attend to different points in space, first the eyes need to rotate so that the brain can fuse the images received by each eye. Then the eyes need to adjust their focal lengths to make the image on the retina becomes focused.[6] The task in the experient includes accommodation process of human eyes for near object, as participants are required to check information displayed at different positions. In addition, the head movement during the task would also cause vestibulo-ocular reflex (VOR), to help stabilize images on retina.

From visual physiology to visual psychology, another important area related to the course is the perception of depth. It refers to the visual ability to perceive world in 3D. A depth cue is derived from the photoreceptors or movements of both eyes, which is a stereo depth cue. In our cases, participants need to give their feedback about comfort of different position, which is exactly based on the depth cues they received during the tasks. In other words, how the distance changes the preference of display is one of the main goals to investigate in this paper, and this is closely related to the course materials of visual perception.

3.3 Future work

Based on this paper, there are several lines of research arising from this work which should be pursued. First, future studies could address a wider use of glanceable interfaces, including moving and multi-tasking. Thus it would be possible to see whether the preference is relative to the user or the task. Second, the depth from participants and the interface has not been widely investigated yet. More positions could be covered in further studies, so that it could simulate different scenarios better in AR environment .Third, the eye gaze needs be recorded to see the rotation of head and eyes during different tasks. Last, regarding using VR for current substitutions, the practical AR implementations for the near future is expected to benefit future research by a more realistic experiences and feedback. In brief, we can expect the potential power to improve current performance and explore more about glanceable interfaces in the near future.

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Screenshots