Efficiency of Cues in Augmented Reality Environments

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ABSTRACT

Due to the narrow field of view of current augmented reality systems, it is important to consider how to direct user's attention to holograms outside the field of view. One's initial solution for this dilemma could be the use of a visual cue, such as small arrow pointing toward the object. Another solution could be the use of auditory cues, allowing a sound to play from the hologram to the user. This paper tests the efficiency of different cues in order to find which cue will provide the user with the fastest search times at the greatest ease. A study comparing the effectiveness of a 3-D arrow, a mini-map, a guidance particle, an interface known as Halo3D, and an auditory cue showed that the 3-D arrow resulted in not only the fastest times, but the happiest experience. These results give an idea of which cues should be further utilized and which should be abandoned.

CCS CONCEPTS

• **Computing methodologies → Graphics systems and interfaces**; **Mixed / augmented reality**; *Computer graphics*;

KEYWORDS

Cues, Field of Vision, Unity, Halo3D

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1 INTRODUCTION

Advancements in Augmented Reality (AR) technology has allowed humans to turn their world into a video game imposed over the real world. Things that could never exist in the real world now can and now any virtual object can be placed in around real world objects using augmented reality. As with video games, developers struggle with how to assist a user in navigating the virtual world. Currently, one of the best options for Augmented Reality experiences is the Microsoft Hololens. However, the Hololens only has a 35° field of view (FOV), which is quite narrow, making virtual objects difficult to find. In order to direct users attention to holograms outside their FOV, visual and audio cues can be used. This allows objects and destinations to be highlighted and easily tracked.

2 BACKGROUND

Dillman et al. recently reported on potential frameworks, using video game style visual cues, for use in augmented reality navigation. In the report, notable visual cue techniques used in video games are highlighted and examples of how some could be applied to an augmented reality application were created.

Another report by Perea et al. detailed the creation of another form of visual cue. This cue, known as Halo3D, is designed to signify if there are off-screen game objects, the direction of the objects, and also the quantity of objects in said direction.

Broderick et al. published a study that identified the usefulness of sound in a 3-D environments to navigate user's through a body of water. Another study observed the effectiveness of visual guidance techniques in a surgical environment [5].

3 METHODS

The testing program was created using the Unity Engine. The user was instructed to find off screen game objects using the guidance of the five different directional cues. Game objects were randomly placed around the user. Once the user taped the object, it disappeared and another object appeared at a predetermined angle from the last object.

Cues

The four visual cues tested were a navigational arrow, a map, Halo3D and a guidance particle. In addition, sound was used for the fifth cue. The arrow was positioned at the bottom of the user's gaze and points in the direction towards the game object. The mini map was also stationed at the bottom of the user's gaze and rotates as the user turns his/her gaze. Another camera was virtually stationed above and follows the user, and it points downward towards the user and the objects adjacent to the user. As user rotates, so those the other camera, and its image is placed on to the map. The third visual cue was referred to as the Halo3D indicator. The indicator was a UI screen placed in front of the user. If an object appears to the right of the user's vision, a red semi-circle will appear in that direction. As the user moves to that direction the circle will shrink. Once the object was in view, the circle is nearly invisible. The same applies in the opposite direction. This was only a one-dimensional indicator and will only indicate that an object is to the user's left or right. The final visual cue was the guidance particle. The particle flew towards the game object from the gaze of the user and motions above the object to emphasize its arrival. If the user failed to follow the particle, the particle would return to the user after some time and then fly back to the object. As for the non-visual cue, sound was played from the location of the object. Using spatial sound, the user would use his/her hearing to find where the missing object is.

Testing

In the beginning of the experiment, the user used the voice command "Start" to begin the training module. In this module, the user was introduced to the five cues that will be tested. Once the user can identify objects at an average speed, the main experiment would commence.

In the main experiment, the user performed multiple runs of identifying game objects with each visual cue. Once a run with a visual cue was finished, the necessary information was saved to a text file.

In the case that the user may want a break from the study, the application was able to save it's data between cues tests and when the user re-opens the application, the user could start wherever he/she left off.

4 RESULTS

Seven subjects were tested. Each subject adjusted the speaker of the HoloLens to their liking, and only one subject chose to take a break due to dizziness from turning.

Testing Data

The data was separated into four ranges of azimuth from which the object was from the user's field of vision. A Tukey test revealed that in the $45° - 90°$ and $90° - 135°$ azimuth tests, the arrow had a significantly lower average time than all of the other cues. In addition, the particle resulted in significantly higher times on average in every range of tests.

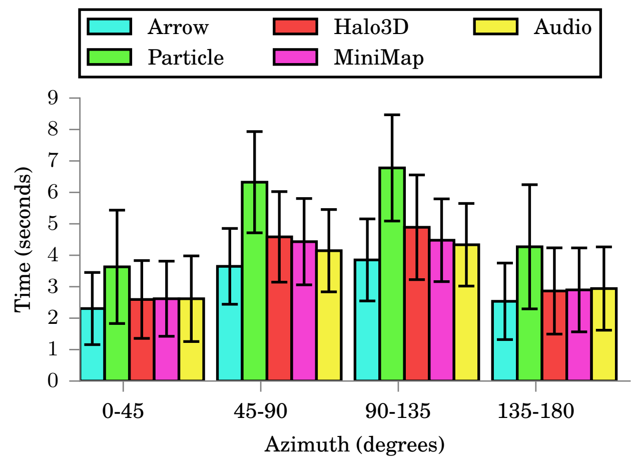

Figure 1: A bar graph of the average time and standard deviation of the five cues tested, split into $45°$ intervals.

User Preferences

A majority of the user's chose the arrow as their favorite cue to use, noting the speed at which they could find the objects with it. The sound cue took the second spot while the Halo3D and mini-map cue tied for third. With that being said, the particle was chosen as the least favorite cue, again noting that the speed of which it moved to the object was too slow for them.

5 DISCUSSION

Going forward, there are some improvements that could be made to the study. These improvements particularly apply to the particle and Halo3D cues.

The particle was programmed so that it would slowly accelerate from a standstill to its maximum speed. This was to prevent the particle from leaving the user's gaze before the user realizes the test had started. The speed resets to zero once it reaches the target. In hindsight, I would have kept the speed at the its maximum after the test had already started, as opposed to routinely resetting it after every time it touches the target. There were also instances where the particle would not start directly in front of the user, leading to some confusion from the user.

The Halo3D also could have been improved. While it can indicate what is to the left or right of the user, it could not indicate whether an object was behind the user, instead treating it like it was in front of the user. Considering that it had

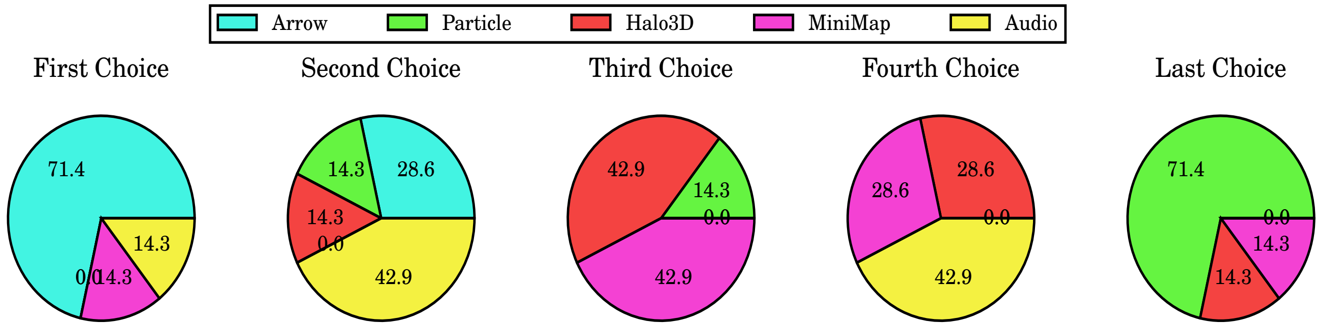

Figure 2: Each pie graph indicates the cue preferences from the users. The graph is ranked from most helpful (first choice) to least helpful (last choice).

the second lowest time from the azimuth range of 135-180, it's possible that it could have had the fastest time in that range had that been improved.

A noteworthy observation in this study is that the audio cue, which does not obscure the vision of the user in any way, performed almost as well as the leading cue, the arrow. In the azimuth ranges of $0° - 45°$ and $135° - 180°$, there is no significant difference in times between the arrow and the audio cue. In the ranges of $45° - 90°$ and $90° - 135°$, the audio cue manifested the second fastest times behind the arrow. This could suggest that the sacrifice of screen space for the sake of a prominent navigation display results in a trade-off.

It is also possible that combining the audio cue with another visual cue could also lead to a faster search time, as indicated in Arce et al..

6 CONCLUSION

The 3D arrow was shown to be significantly more effective at guiding users attentions to holograms outside their FOV. User's preferences largely aligned with localization speed of a cue, with the arrow being mos preferred. Naturally, the acquisition of more subjects would be needed to confirm the above results.

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