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Object Selection in Augmented Reality

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Abstract

This work aims to find a more suitable object selection method for cluttered environments in the space of Augmented reality. It is a response to the development of applications focused on industrial tasks in which the user is able to create and remove virtual objects dynamically, which often results in the creation of object clusters. This paper describes an experiment in which respondents had to complete an object selection task with three distinct selection techniques. Respondents were introduced to the testing scene and each selection method. After introduction, they would complete a series of object selections in randomized order with every method. The results of the work show how respondents reacted to various selection methods. We identified that the selection method with a list was the most accurate and capable in occluded environments. The thesis describes the strengths, weaknesses, and suitable usages of all three methods.

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1. Introduction

Augmented reality provides better and faster methods for executing complex industrial tasks. However, most conventional object selection methods are not suitable to be used in such cases because we cannot control occlusion in such environments.

Objects are created and removed by the application users, which can lead to cluttered environments and potentially unaccessible places due to real-world limitations. For this reason, we need to find a new method for selecting objects that will outcompete the current ones.

Many interesting solutions were introduced in the work by Yin et al. [1]. Most of them work in a two-step process. Firstly, they narrow down the selection to what will be potentially selected. This can be achieved by placing an object, cone, box, or bubble into the space where the user is looking and then retrieving all objects, that are in collision with the placed object. Secondly, they let users choose from the narrowed selection by displaying those objects in a 2D, uncluttered setting. Where they can be easily picked by Direct Touch. In the work by Kapinus et al. [2], two methods were used that worked on a similar principle. They take clusters of objects based on a sphere that collides with them, and then all the objects are displayed via a systematic user interface. A spatial hierarchical menu divides the potentially selected objects into quadrants based on their class. The menu is recursive until a specific object is chosen from it. The selector menu displays them in a list, and an object can be selected by clicking on its representation in the list.

In our attempt to find the best solution for this purpose, we started with a simple user study in which we experimented with participants to find an intuitive selection method. Most pragmatic methods revolved around already existing solutions, such as the Selector menu. We also identified one method, selection by cursor, which was not mentioned in previous papers. We decided to conduct an experiment where participants had to complete tasks in an occluded environment to find which method was most suitable.

An experiment was done with 16 respondents, and data was collected to represent their accuracy, speed, movements, and more. Direct Touch was the fastest method, with a mean completion time of 97.29 seconds. It was faster than Cursor by 20.01% and faster than List by 57.48%. List was the most precise technique, with a mean precision of 88.89%, compared to Cursor with 79.86% and Direct Touch with only 70.95%. Most of the participants tagged List as the most preferred method for occluded environments.

2. Experiment

The experiment consisted of three runs, one with each method, and after each one, a questionnaire followed. The order of the methods was randomized for each individual. Every participant had dedicated time to get familiar with each method before their test run. The post-run questionnaire consisted of a task load part and a physical and psychical load part. At the end, participants ordered methods based on their preferences and were encouraged to provide any feedback about individual methods.

A testing app was created in Unity[3] and allows testing of all three methods. The testing environment consists of 54 manually placed objects and arranged occlusions. Objects were classified based on their size. There are 6 big, 30 medium, and 18 small objects.

Sixteen volunteers have participated in the experiment. They consisted mostly of students between 18 and 26 years old. They scored 4 on a scale of attitude towards technological innovations, where 1 meant that they dislike new innovations and 5 meant that they are thrilled for new technologies.

2.1 Selection methods

Direct Touch selects an object by directly clicking on it Figure 1. Cursor has a marker in the middle of the screen and selects objects when pointed at and clicked on a Select button Figure 2. List has a marker in the middle, constantly sending a ray and creating a bubble at a point where it hits. All objects that collide with this bubble are sorted by distance, and their list member representation is available in a List. Furthermore, a feature was added to the list that allows the user to freeze the list for the duration of holding the "Freeze" button Figure 3.

3. Results

The List was ranked first as the most preferred selection method. It was most preferred by 50% of participants, followed by Direct Touch 31.25% and Cursor 18.75%. A detailed preference ranking graph for individual methods can be seen at Figure 4. Most respondents who loved List also hated Direct Touch, and vice versa. Mainly for this reason, the Cursor was often voted second.

The fewest errors were made with the List with $\overline{x} = 11.11\%$ and $\sigma = 12.61\%$. The standard deviation is quite high, and the reason is explained in Section 3.1. The second-best was the Cursor with $\overline{x} = 18.52\%$ and $\sigma = 5.56\%$. Last was Direct Touch with $\overline{x} = 29.05\%$ and $\sigma = 16.29\%$. Figure 5

The fastest method was Direct Touch with $97.29s$ and $\sigma = 29.88s$; the second fastest was Cursor with $116.80s$ and $\sigma = 18.70s$; and the last was List with $153.22s$ and $\sigma = 34.39s$. Figure 6

As mentioned in Section 2, the objects were classified based on their size, which provides further information about their suitability for different uses. Figure 7

3.1 Importance of freeze

When investigating the high standard deviation, which resulted in List accuracy, we found that some respondents didn't use all the features that were provided. We looked through the data on freeze usage and found that respondents who didn't use freeze functionally had significantly worse performance. Figure 8 If we were to account only for participants who used the List with freeze functionality, then we would end up with precision $\overline{x} = 6.75\%$ and $\sigma = 5.12\%$.

4. Conclusions

The main takeaways from this work are:

- The Direct Touch is best for scenarios where the scene is static and developers can assure that objects will not overlap. It performs extremely well with bigger objects. There is little to no need to explain and get familiar with this method, because it is what people already use on a daily basis.
- The Cursor has good precision and timing but is not the best for highly occluded environments. However, it is well suited for moderately occluded scenes. It requires a bit of coordination for aiming, which makes it slightly more demanding than Direct Touch.
- The List is suitable for complex tasks requiring work with highly occluded objects. Some users might need to get familiar with the method first, as it requires coordination of both hands to achieve great results. Great precision.

The results of our study indicate that for occluded and small targets, the performance of the List and Cursor outperforms the Direct Touch.

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References

[1] Jibin Yin, Chengyao Fu, Xiangliang Zhang, and Tao Liu. Precise target selection techniques in

handheld augmented reality interfaces. *IEEE Access*, 7:17663–17674, 2019.

[2] Michal Kapinus, Daniel Bambušek, Zdeněk Materna, Vítězslav Beran, and Pavel Smrž. Improved indirect virtual objects selection methods for cluttered augmented reality environments on mobile devices. In *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, pages 834–838. IEEE, 2022.

[3] Unity. Unity. online, 2024.