

Virtual Reality Project Report

Snow Globe Technique, Group 7

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Fig. 1. Initial sketch of Snow Globe Technique.

Abstract— This report is a documentation of the "Snow Globe Technique", a Virtual Reality selection tool that sets out to adress problems of selection of occluded objects in cluttered spaces. It goes over the original paper that contributed to the idea as well as detailing the design objectives the technique sets out to accomplish, the way development was handled and structured and finally how it was implemented.

During the development of this technique, a small user study was made in order to further comprehend if the speculation that this new technique can be helpful and easy to understand, is in fact true.

It is concluded that the technique is quite succesful in helping users better understand their surroundings and navigate through cluttered environments to select specific objects. Although generally a success, in order to be implemented, this technique need to be improved, polished and have a game or application in which to implement it.

Index Terms—Virtual Reality, Instituto Superior Técnico, Object Occlusion Selection.

1 INTRODUCTION

The Snow Globe technique started works as an expansion/deviation of the raycast method. Instead of having a sphere move along a ray to simply select the object nearest or inside that sphere, an additional parameter was added to the sphere. The user would be able to expand and shrink the sphere to encompass many objects. Once this space and it's objects are selected, they are copied to the users hand. Once the copies are in place, they can move these around and these movements will happen to the original objects aswell.

This means the user can interact with any object in a scene, even if these are far from the user or not. Besides this, the user can get a good look at the selected scene, investigate it from all sides, by rotating the scene in their hand.

So apart from being able to reach any object in a scene and select multiple objects, it is also possible to look at the selected scene and look at it from diferent positions wihtout moving, giving the user either a better look at the objects or letting the user find obstructed objects

that weren't observable from their original position.

1.1 Reference Paper

The reference Paper used for this project was: "Exploring the Effects of Environment Density and Target Visibility on Object Selection in 3D Virtual Environments" [2]. This paper discussed two, now well known, techniques for object interaction in VR with a HMD and trackable controllers. These two techniques were called "Raycasting" and "Bubblecursor", which both helped with interaction and selection of objects in cluttered virtual spaces. Raycasting helps with reaching objects that are far away from the user with higher precision than a simple laser pointer, due to the added dimension of scrolling through the z axis of said laser. The Bubble cursor helps the user grab objects that are near them, without perfect precision of their hand position nor the perfect relation of real to virtual hand position. This is done by an ever expanding bubble, that starts at the grabbing hand and stops when colliding with the nearest object.

Both these methods were created to help users in cluttered spaces by either letting them reach further without much hassle, or making the selection of nearby objects easier and simpler. Inspired by this idea of making a method that helps the user in VR, the team looked at what these methods didn't fix. The conclusion was that cluttered environments would also obstruct a lot of other objects, hidden behind

many or larger ones. Small objects would also be difficult to identify and select at higher distances.

This technique tries to fix these issues, while keeping the added benefit of the user not needing to move around either in real or virtual space.

2 RELATED WORK

Apart from the before mentioned paper that was used as reference, the team also took inspiration from the paper “Virtual reality on a WIM: interactive worlds in miniature” [1].

VR on a WIM showed this idea was a good one, because it contained observations about possible problems, specially when it comes to “establishing the mapping between objects on the WIM and objects in the life-size virtual world” were “None of the users expressed problems” [1]. Generally some of the most important features observed in that paper also apply to the Snow Globe:

- intuitive use of the WIM metaphor;
- multiple, simultaneous points of view;
- improved visual context;
- removal of occlusion and line of sight problems;
- general applicability across a wide range of application domains;

Lastly, “Arm fatigue was not a major problem.” and this was of special value to us, as one major focus during the development of the Snow Globe technique was to make it as simple as possible, with the least amount of strain on the user, because VR doesn’t have many accessibility options for people with disabilities.

Other related work that is less an inspiration and more a competition with this new method, is the widely used teleportation and the other multiple walking around methods used in most VR applications with a larger scale than arm length. These let you reach objects at a distance and see occluded spaces easily, just like the Snow Globe Technique, but in order to interact/select object, they need to implement additional methods, like Raycast, or make the user move their body in order to grab these objects with their Virtual hands. This can be a more immersive way of interacting with the VR world, but of course brings a larger strain to the user, as it necessitates much more movement. It also takes away the possibility of having multiple perspectives, which in this case are the Virtual World and the copy of a small scene on the users hand.

3 SYSTEM DESIGN

As part of the project, it was asked of the team that development be split in three milestones. So the team set out to figure out the best way to develop this technique and ended up with the following roadmap:

- Create copy of selected objects using a raycast and volume selecting sphere.
- Create visual representation of the snowglobe and apply interactions with the copies created.
- Create a proof of concept for the technique.

The team focused development on the Oculus Quest 2 system, considering a member of the team had the system and that would provide easy access throughout development. The team also decided the application would be made using the Unity Engine.

For each milestone, 2 weeks were given to bring to fruition the set of objectives, followed by a presentation. What follows is a detailed documentation of the development.

3.1 First Milestone

For this milestone, the objective was to get accustomed with using Unity for VR development and also have the base of the whole technique up and running. For that the team decided to keep things simple.

The starting point was the creation of a simple 3D scene, consisting of basic shapes that could be easily created and understood. With the scene set, development was started on the two basic features that were inspired by the paper:

- A raycast that was “shot” from the Oculus remote in the direction the remote was pointing.
- A sphere that could travel in the raycast with a variable volume controlled by the user.

The marriage of these two features allowed the selection of a point in 3D space and the creation of a selection that would allow the creation of the copy.

With these two features fully working, the team moved on to the creation of the copies. The idea was that thanks to the sphere, the user could now “select” every object the sphere was touching and copy them, as a scaled down version, to the top of the controller that was not doing the raycasting.

The team reached the end of this milestone with every objective met. After the presentation, feedback was mostly good, but the professor pointed to the necessity of having a good use case for this concept, so the objective of finding one was added to the second milestone.

3.2 Second Milestone

With the added objective of finding a use case, the team went on to brainstorm ideas of one. The team reached the conclusion that one sector could benefit greatly from this technique, and that sector was: Interior Design. Why? Because of the advantage this technique brings when interacting with the world without the need to move, which brings the feature of changing placements in a room while knowing exactly how it will look from a specific point of view.

With this new objective, the focus the proof of concept would have on the 3rd milestone was decided and the team moved on to the other objectives for this milestone: be able to interact with the copies created while, at the same time, those interactions affecting the actual VR world.

The basic idea seemed simple enough, every interaction made in a copy would translate directly to the original, for that the user would use the remote, that didn’t have the snowglobe, to interact with its components, this means rotating and moving the copies, and with the other controller the user would control the snowglobe position and rotation, but the team ran into and had to fix some problems:

- Since the team wanted the snowglobe to be able to rotate, so other views of the copied objects could be possible, the team needed to do it in a way that wouldn’t affect the real objects.
- Since the copies were a scaled down version of their counterparts, a 1 to 1 translation from the interactions would be impossible, so at the time of conversion the team would have to take that into account when dealing with the translation.
- When both of the previous points were dealt with, the team also had to keep in mind, that an interaction made on a rotated snowglobe could be “mirrored” to what would actually happen in the VR world.

By the end of this milestone, the base technique was close to fully completed, it’s basic features were all implemented and worked according to the original idea and what was expected of them.

3.3 Third Milestone

At the start of this milestone, it was time to develop the visual aspect of the technique and its proof of concept based on the use case: Interior Design.

Unfortunately, the team quickly understood that the original visual metaphor of the snowglobe was taking more from the technique than adding. Finding a way to contain the copied objects to the interior of the visual sphere/snowglobe without compromising the ease of accessibility and readability to and of the copies themselves was becoming impossible.

- **Accessibility:** If the restriction of a copy staying inside the snowglobe was kept at all times, the user would have its movement options and interactions restricted by the snowglobe's edges. This would lead to sub-optimal selections that would then necessitate the user to make a new, better selection.
- **Readability:** The snowglobe needed to be easily understood and viewed, so the confines of which interaction was possible would be instantly known, for this a faint color was used on the sphere, this would then lead to harder readability of the copies colors, especially if the said copies were small in scale.

Taking that into account, the team decided to abandon the visual of the snowglobe in exchange for a better user experience. The team went on to develop the proof of concept, the objective was to have a simple scene related to Interior Design that would show the possibilities of this technique and its advantages. For that, the scene would need to have:

- A recognizable look that automatically connected the scene to an Interior Design context, so the tool could show the advantage of being able to move furniture around without the need to move and the ease of use of the technique to do so.
- Furniture set up in a way that could easily demonstrate every feature of the technique.
- Hidden furniture that, through the use of this tool, would be revealed, thus showing the use for this technique when dealing with cluttered spaces.

When the team reached a scene that met all of these requirements, development on this milestone was complete.

4 SYSTEM IMPLEMENTATION

4.1 Raycast and Bubble Movement

When the team started working, controller tracking was already provided by unity XR. In order to draw the raycast, a simple line renderer was made taking the direction of the right controller and a long length. To create a bubble for volume selection, the user would have to be able to select the spheres radius and distance along the raycast, to do so the left joysticks Y axis was used to manipulate the scale of the selection sphere, this value would be later used for scaling the clones and distances, a variable called distance was also kept, which was manipulated with the right joystick Y axis and used to keep track of the bubble position along the raycast. To get the spheres position, a sum would be made using the left controllers position, and a normalized vector with same direction as the raycast times the distance variable.

4.2 Object Selection

After the sphere is covering the needed area the user can select that area by pressing the X button. In order to know what the sphere is selecting, list of the objects that are currently inside the sphere is kept. To do this, the objects are added when they enter the area and removed when they exit to avoid duplicates. Only objects that are tagged as "selectable" can be so, and haptic feedback is given to help with this process.

4.3 Creating The Replicas

When the user has successfully selected the list of desired objects, the previous lists of objects(snowglobe.orig) and replicas(snowglobe.objs) are erased. The selected objects are then added to the snowglobe.orig and create replicas with their size scaled according to the selection bubble scale. The positions of the replicas is chosen by scaling the distance vector between the original object and the centre of the selection sphere.

It is then scaled appropriately and applied the resulting vector to the center point above the left controller, the center of the Snow Globe so to say. The left hand translation must be added to every replica, every frame, in order to keep the replicas centred on the left controller.

4.4 Moving Objects

To move an object the user must be in the right mode, meaning they must already have the "miniature world" on their hands. From here the user grabs the object in the miniature and it moves proportionally in the real world. To grab an object the right controllers tip must be placed on top of the object and when the trigger is pressed the object is now being grabbed, to facilitate this the right controller's collider has been modified to help select with finer detail.

4.5 Rotation

When a replica is grabbed, its distance is maintained to the selecting hand to avoid big jumps in the position of the original object. When a replica is moved, the original object moves in real time. To do so the corresponding translation vector is calculated, then the scale and rotation so it can be added to the real object.

It is also possible to rotate the miniature (the scene copied to the hand) and the grabbed object. To rotate the miniature, the right joystick is pushed in the X axis. When the replica, the grabbed object, is rotated, the real object is also rotated. To do this, there are three rotation modes. With each mode the user can rotate in a different axis using the right joystick Y axis. The colour of the ball in front of the right controller represents the current rotation axis mode, if the ball is red rotation is in the X axis, green is the Y axis and the Z axis when it is blue.

5 USER STUDY

When attempting to fully analyse the efficiency of the tool, it was decided to construct and apply a battery of user tests that aimed to include the three age spans that were considered well suited for the use of the tool: Teenagers (13yo to 17yo), Young Adults (18yo to 29yo) and Adults (30yo to 60yo).

This tests were conducted after and open call for participants, in person, and followed a strict script that the team developed and is attached to this document. The results of the tests are also attached and provide enough info to take some conclusions:

- Previous experiences with VR hugely influence the result of the tests;
- Between Object Seleccion, manipulation and snow globe manipulation, it is the last that is the less intuitive;
- Speaking about improvements, the visual representation of the object rotation axis seems to be the most urgent one.
- The usefulness of the tool is verified by the results.
- The most recurrent use case suggestion seems to be gaming.

All the tests happened without any major conflict, respecting the script and providing a high level of trust and reliability.

6 DISCUSSION AND FUTURE WORK

Since its inception, the team wanted this to be a method that is supposed to be a tool and not a specific product or software. A demonstration was created to try to best show off how useful this method can be. It's a technique that can be easily paired with many other softwares or games. Of course it can also be implemented for specific uses, like the case of interior design.

Is also a belief that its most important qualities are probably the ease of use and the lack of movement necessitated from the user. This can be quite helpful to people with low movement capabilities or full disabilities and, because of that, it is possible to expand the use of VR to people who usually are not able to easily interact with it.

To prove these assessments, some user tests were run, but thanks to the ongoing COVID-19 situation that has been present throughout the

development of this tool, such activity proved to be more difficult than expected and the team could not run the amount of tests desired to fully prove them. But from the ones done, the following observations were made:

- The intuitiveness of the selection method seems to be very good. Most testers got the idea and how it worked quickly.
- The interaction with the copied objects was also very successful, and most testers got up to speed with how it worked intuitively.
- On the other hand, interaction with the snowglobe and rotations on copies, basically every process that relied on the analogue sticks, except the ones related to selection, were not very intuitive and most testers had problems with it.
- Most testers complained about the way the copy rotation worked, so while technically working, it was not the most intuitive or understandable way of achieving the desired objective.
- Testers were very receptive to how the tool worked overall, and most were able to complete the desired tasks without much difficulty.

To better understand how this technique works when compared to other selection and movement solutions in the VR world, it would be needed to make tests with people that were more used to using VR or make a completely different demo that incorporated these solutions. So, if possible, in the future it would be done.

To further prove the assessments made, the team would also like to get in contact with businesses that could benefit from this tool to fully understand if what is expected is true or not.

6.1 Improvements

As a project done in one semester by students with limited experience in VR or Unity, this project would need a lot of improving in terms of polish. It looks very basic, and some of the implementations are not well communicated to the user visually. It is absolutely necessary to know the controls beforehand as many buttons do many different things, though users can overcome the learning curve with repeated use of the tool. One of the main objectives, if improving this build, would be to streamline controls, improve ways of interaction with objects so they're more intuitive and satisfying and better communicate visually how the technique works, be it UI or subtle visual cues.

6.2 Future Work

Looking at the future development of this technique, looking at the teams feelings and feedback received, further development could definitely improve the tools functionality and intuitiveness. Development would mainly focus on improving the mechanics themselves instead of a possible use case.

The part that would need the most urgent attention would be rotation of copies and interaction with the snowglobe. To better the rotation of the copies it would be needed to find a way to make rotations based on controller gyro movements instead of analogue stick movements, without exchanging the precision the latter brings with the intuitiveness the other does.

It would also be important to implement different "modes" for different types of activities. This would be done after market research with the contacts made with businesses, to make the tool more versatile and complete. What this additional work would entail is still unknown, so an estimation of how long it would take is also unknown.

With these additional developments, this new tool could become market ready and make the VR world a little bit better.

7 CONCLUSION

After the discovery of this new approach to VR 3D object selection and manipulation, and a set of user tests with results proved its efficiency and need, the authors conclude that this was a successful process of concept development and has the potential for a future and more detailed

work journey. It's also important to note that the user tests, even them occurring during the Covid-19 pandemic and requiring special cautions, were a determinant factor for the full understanding of the technique presented and its limitations.

ACKNOWLEDGMENTS

The authors wish to thank Ken Pfeuffer and Chris Clarke, for the references on VR papers and initial support and motivation, and Augusto Esteves for pointing them in the right path on figuring out how to demonstrate their technique.

Special thanks to Daniel Gonçalves for providing his VR unit to be used in the development of the technique.

REFERENCES

- [1] R. Stoakley, M. Conway, and Y. Pausch. Virtual reality on a whim: Interactive worlds in miniature. 02 1970. doi: 10.1145/223904.223938
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The Snow Globe Technique

User Test Script

Test calendar: 4th – 8th January 2021

Targeted audience: Teenagers (13 to 17 years old), Young Adults (18 to 29 years old), Adults (30 to 60 years old)

Number of participants: 5 per age class

1 – Introduction

First, let us thank you from your collaboration on attending our call for participants. My name is Daniel Gonçalves, I'm going to assist you during this experience and I'm able to answer any question that you might have before, during, or after the procedures that we are going to purpose to you. My colleagues, Rafael, Henrique, José and Pedro will assist by dealing with the technical part of this experience and taking notes that will make us able to take some conclusions at a future time. Is important to say that we decided to not record this process and the personal information that you gave us will be analyzed and only associated with the results behind a persona that we created for each participant. On top of this, this is a test for our prototype, and never for your physical or mental abilities, so your actions will never be right or wrong.

Due to the actual health situation related to Covid-19, all the equipment's you are going to use were fully disinfected a total of three times after they were last used with an alcoholic solution indicated and regulated by DGS, the official Portuguese health organization responsible for all things covid-19 related. On top of this, you have a vial of disinfectant gel at your disposal and all of us change masks between tests. We will also disinfect our hands every time we need to touch the equipment you will be using and we will also keep social distancing.

As we indicated at the sign-up form for this activity, we are MSc students from IST, and we will be testing, with your help, a Virtual Reality 3D selection and interaction tool that we developed during this last semester. The test will take no longer than 20 minutes and we will be using a virtual reality kit called Oculus Quest 2.

Before we begin, let me aske you if you have any doubt or concern that you would like to share. I will be happy to help you with whatever you may need.

If you do not have anything else to add, I want to once again thank you for your time and we will start with the test.

2 – Introduction to VR (If the participant answered at the sign-up form that he/she never used a VR headset, than proceed with this section, otherwise, it can be skipped).

When analyzing your sign-up form, we noticed that you never had an experience with a VR system, so we will start by explaining you the basic controls, have you completely comfortable with the equipment that you will use for the test and introduce you to a very simple and fun demo VR experience called “First Steps for Oculus 2” that will help you with both the gear and the software.

Starting with the equipment itself, Rafael will help you handle it and get you comfortable.

(Get the participant introduced to the physical interface of the Oculus Quest 2, helping he/she put it on and try the controllers).

Now that you are all geared up, let's get to the fun part. Henrique will be with you while you try the “First steps for oculus 2” app. At this app, you will have the freedom to explore the controllers and your presence inside the VR environment.

3 – User test

Before we begin, is import to say that you have all the right to ask us to stop at any time for a break or even if you feel that you can't continue. We just want you to be completely comfortable and for you to have a great time.

Once again, if you have any doubt, please tell us.

Let's start the test.

Now that we have our app running, you should feel like you are inside a modern apartment. You can see two floors, a living room, dining room and kitchen at the lower one and a bedroom at the upper one. Can you confirm this for me?

We will go through a series of small task that we will ask you to preform and we will explain you the details and the controls needed at each time. Once again, if you feel the need to clarify any of our instructions, be our guest.

3.1 – Selection

a) Let's start by selecting the sofa and the table that are right in front of you. For this to be done, you will need to keep the grip button at the right controller pushed. This will activate what we call “selection mode”.

b) You now have a line coming from your right controller and a sphere. This spere is your selection volume. Increase and decrease the volume the sphere by using the left controller joystick.

c) This selection sphere runs alongside the line that you see in front of you. Change its position by using the right controller joystick.

d) You now know to change the position and size of the selection sphere. All the objects inside the sphere and that were previously defined as selectable (this just means that you feel a small vibration when including it inside the sphere), are now capable to be selected. Please, select the sofa and the table that are in front of you.

e) Now, you just need to confirm your selection. This will create an interactable copy of the selection on top of the left controller, what we call “Snow Globe”. You can do this by pressing the X button on the left controller. Just a little tip: The bigger the selection sphere is, the smallest the copy of that object will be on top of the left controller.

3.2 – Snow Globe manipulation

a) Now that you have the sofa and table selected, you can exit the selection mode, by releasing the right grip button, and manipulate the snow globe itself to better see the objects that you selected without influencing them directly. You can start by rotating the snow globe, by using the joystick on the right controller.

b) You can resize the snow globe as well. This will simulate a zoom effect. To do this you just need to use the joystick on the left controller.

3.3 – Object manipulation

a) Apart from the selection option, the object manipulation capability is another one of the highlights of our design. Any manipulation made to a copy of an object will be suffered by the original object as well. Let's start by grabbing and moving the sofa. To do this, please note that you have a small sphere attached to the front of the right controller. Once you collide that sphere with an object inside the snow globe you can grab it, by holding the trigger button on the right controller. Please, grab and move the sofa.

b) You can rotate objects as well while grabbing them. You just need to pay attention to the small sphere that we talked about in the previous task. Its color represents the axis of rotation: Red for x-axis, green for y-axis and blue for z-axis. You can toggle between each axis by pressing the joystick on the right controller. Please, select the y-axis.

c) Now, we will ask you to rotate the sofa 90 degrees by the y-axis. To do this, and with the y-axis already selected, you just need to use the joystick on the right controller and move it to the right or left.

4 – Conclusion

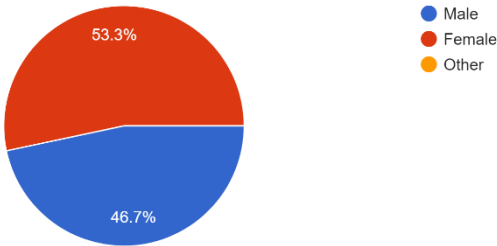
Once again, thank you for your commitment in helping us with this prototype evaluation. Rafael will now help you remove the headset. This is the end of our test. We hope that this experience was as useful to you as it was for us. We will be sending you a quick form to the email you previously provided us and we ask you to be totally honest, so that we can get better results for this test.

Thank you again in the name of all of our team and stay safe.

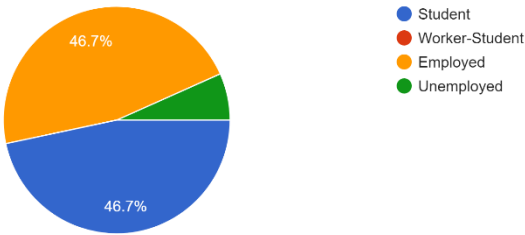
The Snow Globe Technique

User Tests Results

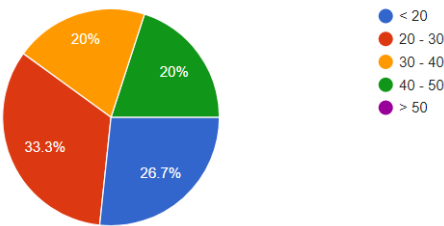
Gender
15 responses



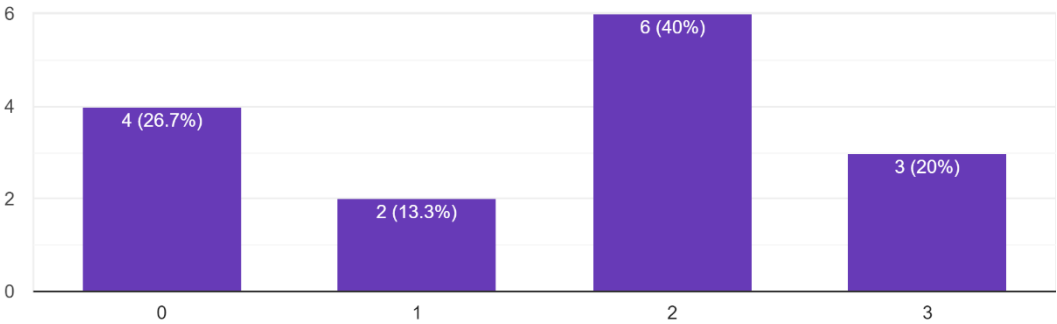
Occupation
15 responses



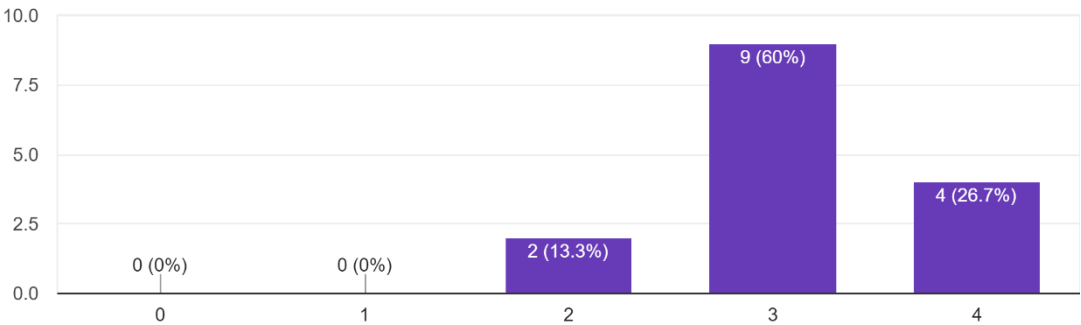
Age
15 responses



How comfortable are you using VR Headsets?
15 responses



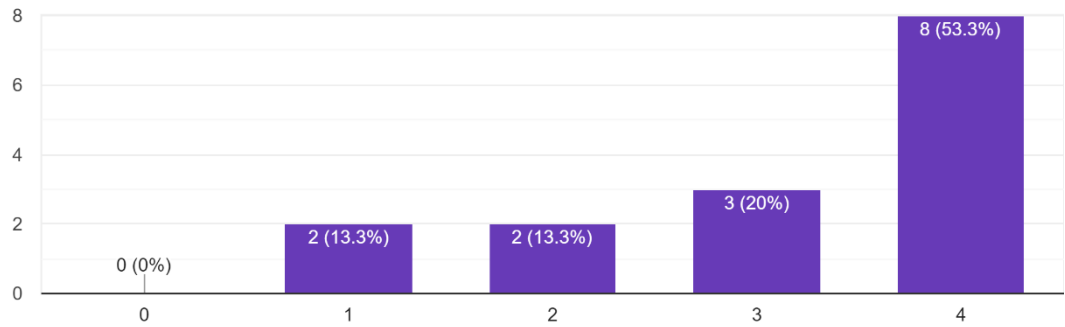
How useful do you find the entire tool in an interior design setting?
15 responses



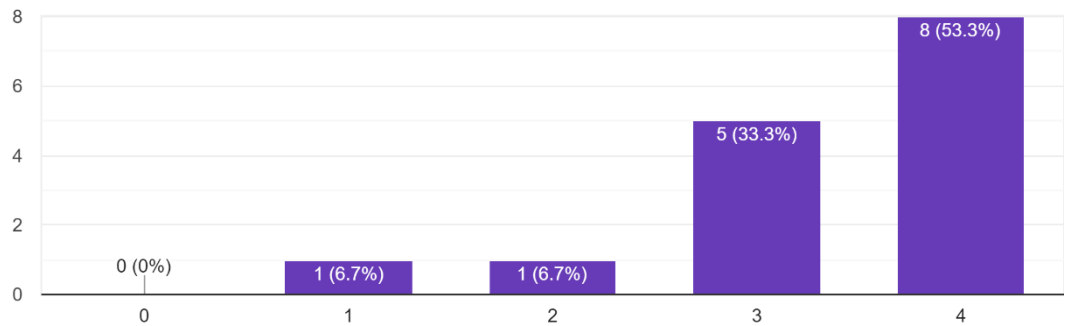
The Snow Globe Technique

User Tests Results

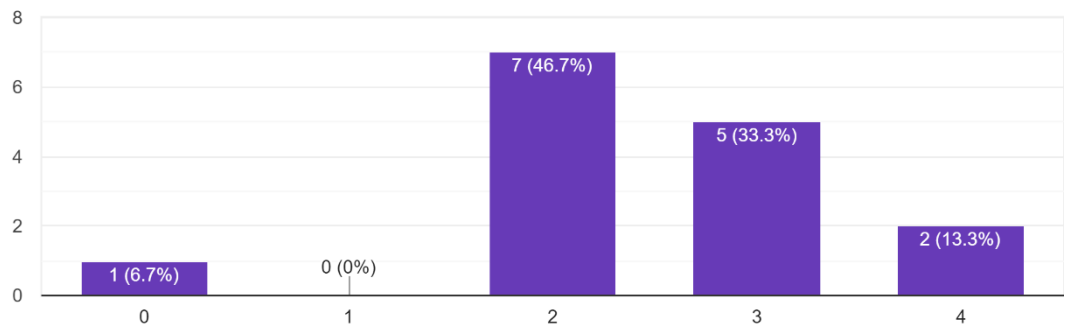
How intuitive did object selection feel?
15 responses



How intuitive did object movement feel?
15 responses



How intuitive did globe manipulation feel?
15 responses



The Snow Globe Technique

User Tests Results

Would you find the tool useful in other applications other than interior design? If so, which one(s)?
entertainment and it could also be useful for engineering where u could use the snow globe to zoom in and have control over smaller pieces of an engine for example
Talvez experiências interativas como jogos.
I see this being useful for other types of design, like Urban Design for example.
Arquitetura talvez.
Architecture
games and educational
Gaming (Escape Rooms)
Don't Know
Don't know
It can be useful in many places
Puzzle Games
era fixe usar em jogos!
VR Puzzles
Civil Engineering
Virtual escape rooms
If you had to improve one aspect of the tool which one would it be?
a way to return an object to its previous position in case of an accidental grab
Uma maneira mais simples de rodar objetos pois senti que demorou muito tempo.
Manipulation of the globe, maybe not using the circles on the controllers.
Mais interações com os comandos e menos com os dois botões direcionais.
The rotation
The rotation is unintuitive
The visual representation of the rotation axis
Highlight the objects that are being selected.
Make a tutorial
weird rotation, a bit hard to remember controls
General lack of polish
Difícil perceber como rodas as coisas
Outline for object selection so its clearer
Add other types of selection volumes
Object movement