

# **VR UI Design for Engineering Applications**

## **Final Report**

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# 1. Introduction

## 1.1 ACKNOWLEDGEMENT

Mr. Tsung-Pin support us a oculus development kit<sup>2</sup> and two razer controllers. Also, Mr. Tsung-Pin provide us some resources about the VR interface design. Tsung-Pin also lead us to his company to show the sample VR interface.

## 1.2 PROBLEM STATEMENT

VR technology is widely used in not only gaming field, but also industry to demonstrate and create the final products for both customers and engineers. Comparing to the traditional computer applications, VR can display the products in real size and change the detail dynamically. What the people observe through the VR device is almost the same with real life.

However, different from the computer applications, which use keyboard and mouse as input devices, the only widely used input device for VR technology is two handle controller; which will be problems when operating or change the product model. For example, if we want to select an item and get its cross section area. In traditional computer applications, we can do so by using mouse to click items and menu; or more conveniently, we can use the shortcut in the keyboard to achieve this function. However, in VR environment, we do not have mouse to select items, and we even do not have menu bars listed on the side or top, so, in order to do this simple operation, we need to cost lots of time.

In order to let the engineers or the customers to do those editing operation efficiently, our team is plan to create an VR UI for the engineering application. By creating the unique menu bars in the VR environment, people can editing the models easily.

## 1.3 OPERATING ENVIRONMENT

We start our design from drawing system such as scratch, then implement our design with softwares such like Unity and Oculus. During the developing process, SDK from OD providers(like C#) will also be included.

Another aspect of operating environment is from user's aspect, and from this perspective the environment is very strict. Since it's VR application, it must be applied indoors and a relatively open wide area. There shouldn't be any other objects but camera and monitor in the room otherwise which could possibly affect user's using experience and even potential hurt users.

## 1.4 INTENDED USERS AND INTENDED USES

We are designing user interface in VR environment for engineering usage, but our potential users are not strictly narrow to engineers. We try to make the interface as simple as possible and make

every user are able to use even first time to VR usage. However, engineers with VR experience can definitely easier to use.

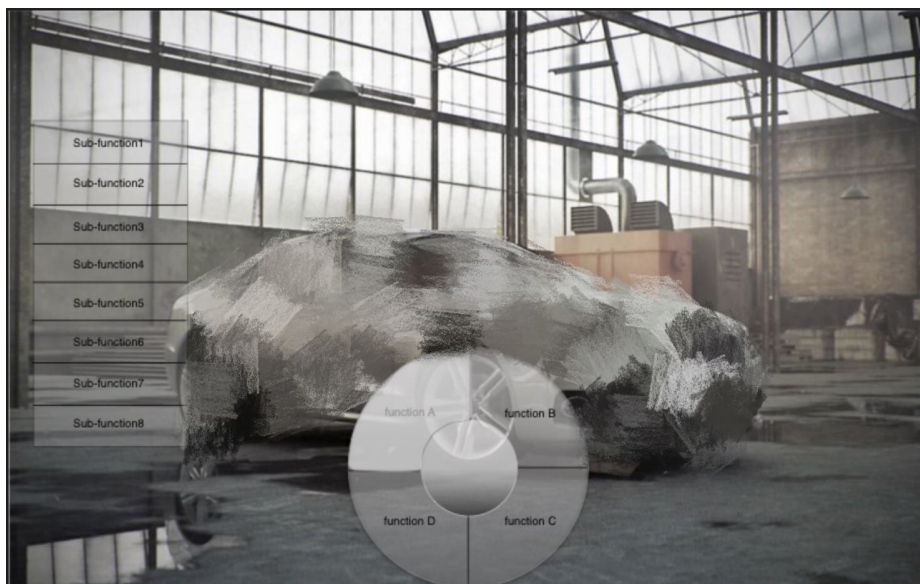
What we are designing for is a software that designing a car in VR environment. Since designing in real material is much more difficult and costly, this new technology makes it easier and more convenient. But designing a car is a difficult process and there are a great number of functions need to be performed. We are trying to make a user interface that could this complicated process as simple and straightforward as possible, even first time user could find it easy to use.

## 2. Design

### 2.1 Original Design

#### 2.1.1 Interface requirements

As a virtual environment application, this user interface should solve the most common issue - occlusion problems. Occlusion means how to manage the UI layers depth. ie. if we are very close to a non-transparent object A, and then we pop up a menu, can we look through the object A and see our brain? if we can, it is occlusion problem and our brain will be confusing.



*Original UI design*

Original VR UI design:

- Background is in engineering relative environment such as factory

- The object we are going to adding function is relative to engineering such as Auto, aeroplane, machine and so on.
- Main menu (circle)
  - Move the controller to the function you want to use. The function which be selected will be highlight.
  - Press the trigger on the controller to the button to go into the function.
  - The menu is transparent
  - Main menu located in the bottom of screen
- submenu (triangle)
  - Move the controller to the function you want to use. The function which be selected will be highlight.
  - Press the trigger on the controller to the button to go into the function.
  - The menu is transparent
  - Submenu located in the left-hand side of screen

### 2.1.2 Usability requirements

This design should be better than the other designs from the ease of use perspective. In other words, this UI should be used easily by users.

The movement we design fulfill the simple usability

- In the circle menu, user can use less arm movement to select the function they want.
- The function options once be selected, it will highlight. So it will easy to see even if the environment is dark.
- The menu put on the side of screen, so it will hard to block user sight once they are doing work.
- Both main menu and submenu are transparent, it will solve the occlusion problem which have negative effect on the usability of VR UI.

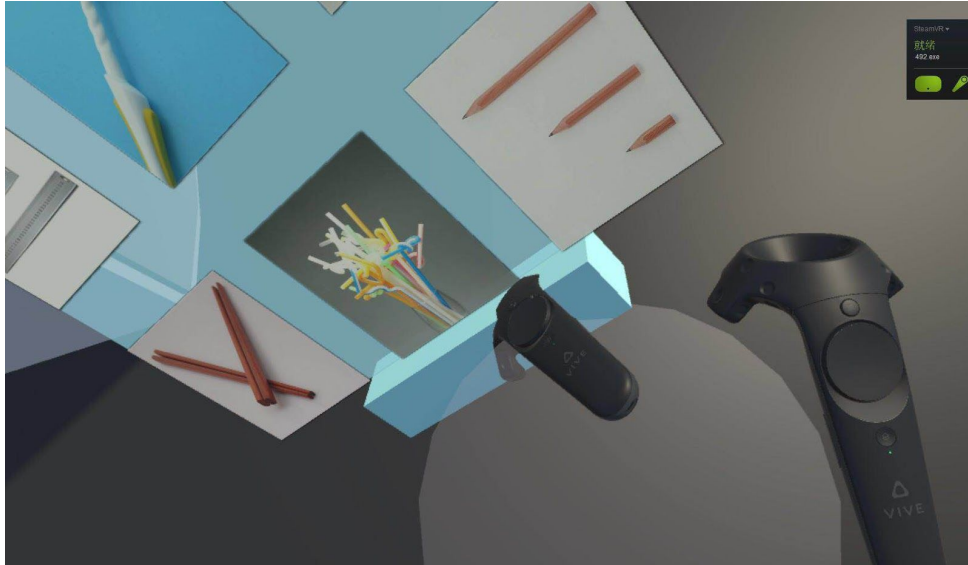
### 2.1.3 Performance requirements

Since we are designing user interface for engineering usage, it needs to support many functions and as for interface, it needs to be smooth when switching between those functions and react immediately when user making operations.

### 2.1.4 Supportability requirements

We make our interface as an executable file and theoretically it could running on every PC that supports VR. Also, a set of VR equipments is also needed and once you have both PC and VR gear, it can be used anywhere. As for project itself, it only supports controllers as their unique input source.

## 2.2 Current Design



*Current UI*

### 2.2.1 Interface requirements

Current VR UI background are in a house. (the background are easy to change)

We have following function in our Interface design

- Floating menu
  - If our menu is overlapped with other objects, the menu will be transparent
  - Menu can be posted and stuck in any places, and can be moved or return to our hands by pressing certain button.
  - Options within menu will be icons or pictures.
  - While a specific function is selected, the menu will become a window shows the states. Eg. if we select function "ruler", the contents within menu will become the result that we measured.



- Tool Belt
  - Tool belt is located lower sight, user need to look down to see the tool belt
  - Two or three commonly used option\tools can be selected and placed in the tool belt. So the function of tool belt is same as shortcuts.

- Tool belt also can fit in by mostly used function. if we want to place another function, we can drag the function out of the belt and then drag the function we want to use into the belt.

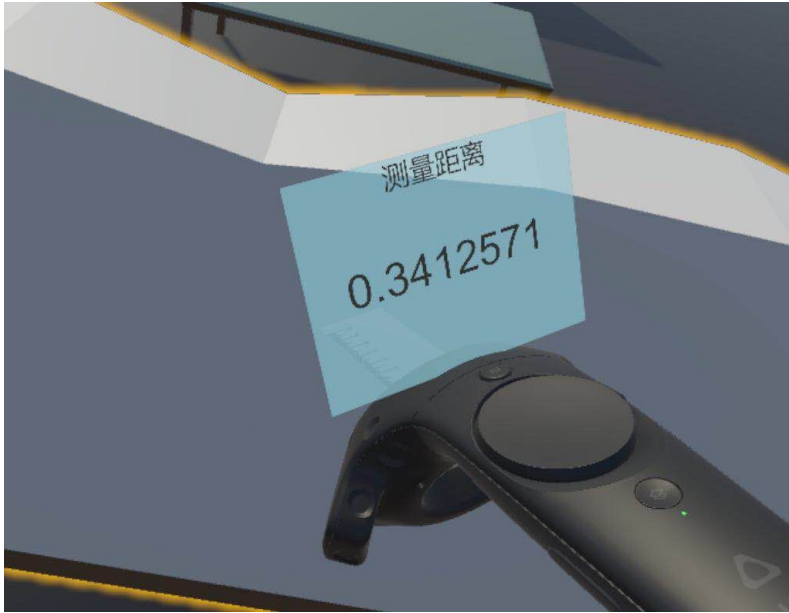


*Tool Belt*

- Figure movement
  - Use right-hand controller point where you want to go (A green figure will show on the location), press trigger button, then you will teleport the point.



- Ruler
  - Measure the distance between two points.
  - The value of distance will display on the top of controller



*Ruler*

### 2.2.2 Usability requirements

1. Floating menu
  - a. Menu can be placed in anywhere we want, so it will not block our sight once we are working on a object. Also, it is a solution of occlusion problem.
  - b. Menu is transparent, so the occlusion problem will not happen.
  - c. The icon of the function in menu bar is the miniature of real object, so it will be easy to find.
2. Tool Belt
  - a. This function is useful in user usability, user can put function which use frequently and favorite function into tool belt(shortcuts), it can make working efficient.
  - b. Tool belt is in transparent. As well as the tool belt is placed lower position and will not block sight of other objects, so it can solve occlusion problem.
3. Figure movement
  - a. Teleport is a good idea which is simple and efficient. Press a button and you can go no matter how far it is.
  - b. Less bug occur



### 3. Risks

As developers, we don't have much VR experience and it is inevitable that somebody may feel uncomfortable when using VR devices. We are afraid that our work will make user feeling not comfortable and dizzy. We try to make the user interface as simple as possible and in our draft design we didn't take object collision and block into consideration, client told us a potential risk which is menu will get blocked by object or suddenly showed up in front of users' sight and scare users. We have been worked a lot to get rid of such potential danger and we decide to sacrifice a little bit convenience and make the menu moveable and assimilating into environment.

Another potential risk is a common problem when using VR equipment that the users' sight are blocked and are not able to see objects from real world and potentially hurt themselves by bumping against objects from real world.

## 4 Testing and Implementation

### 4.1 HARDWARE

HTC Vive, PC that supports VR

We choose HTC VIVE as our VR equipment for it is not very expensive and not very heavy, easy to carry and set up. It contains two controllers for both hands, a headset and two sensors as base stations. Another reason we choose HTC VIVE is that we decide to use Unity 3D to implement our design and it perfectly supports HTC VIVE.

In addition, a PC with great graphic card and large memory that supports VR is also needed, since VR has high requirement for PC and we don't want users use our interface in a laggy environment.

### 4.2 SOFTWARE

Software: Unity 3D, Sketch

**Sketch** is a proprietary vector graphics editor. In our project, we use the Sketch to create the demo so that we can have a preview about our design in our creating idea progress. We made a framework about our UI with this software.

**Unity** is a cross-platform game engine developed by Unity Technologies, which is primarily used to develop both three-dimensional and two-dimensional video games and simulations for computers, consoles, and mobile devices. It also supports to develop the applications in the

Virtual Reality environment. We developed our project in this application. We used C# and Javascript as the script tools in our project.

### 4.3 TESTING PROGRESS

Our testing process followed the general guideline displayed below. We tested as we developed, and demonstrated our project to our client to get feedback every month.

#### General Testing Outline

1. Developer creates empty Virtual Reality (VR) environment
2. Import sample Unity assets
3. Test basic actions (grab and select object etc.)
4. Special Features Testing Phase
5. Tools Testing Phase
6. Final Validation Testing Phase

#### Special Features Testing Phase

- Suspend moveable menu
  - Test menu movement
  - Pull the tools out from the menu
- Tool belt
  - Pull the tools out from the tool belt

#### Tools Testing Phase

##### Ruler

- Test distance/length measurement

#### Testing Results

Through this process, we could develop with close supervision of our client to ensure to ensure that we developed exactly what he requested. We resolved conflict and achieved what we want with special features testing and tools testing. We have an efficient development process that minimized the amount of re-work that needed to be done.

## 5. Challenges

1. In this project, the first challenge for us is coding skills. Since none of us learned Unity and C#, it will be challenges for us to catch up in short time.
2. The second challenge for us is to design an VR interface, which should compile different functions in different engineering field. Also, the VR interface should be convenient to help user to use it.
3. while experimenting with virtual reality, has figured out two factors which have an immense influence on virtual reality UI design: occlusion and convergence. Occlusion means how to manage the UI layers depth i.e the Z order. i.e. what is in front of what? Convergence means the point to which the focus of our eyes meet, also called gaze.

## 6. Future Expansion

First of all, we want our interface supports more functions especially in engineering area. For demo purpose, we only design the ruler function that measure the distance between two points that a user defines, but for engineering usage it requires more functions and we want the interface supports as more as possible.

Secondly, we haven't really resolve occlusion problem when two objects overlaps the back one got blocked, we decide to make menu movable so menu can always be seen when get blocked, but for other objects it's better to make the front one transparent and show the back one. This can be solved easily by adding a paid tools in Unity market but we decide not to since its enough for demo purpose but if put this interface into market it's better to add this functionality.

Last but not least, beautify our UI make icons self-explained and the whole style more user-friendly. A great appearance is a key factor that attracts users make them want to keep using and due to this reason, beautify the whole design is needed in the future.

## 7. References

This website helps us learning the use of the application Unity which will use in our project:

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## 8. Conclusion

The goal of our project is designing a easier and more convenient user interface in VR environment. The current user interface in the VR environment is too complicated and is difficult for the users to control the application. Our project will combine lots of functions in the application so that the users can control the application easier. With our project, the users can achieve their goal easier and faster which can reduce the time spend on their work.

## 9. Appendix

### Setup(design)

- Take research on the article about Virtual Reality.
- Communicate and share ideas found by every team member
- Combine the ideas and create a complete design.
  - In this progress, we made several designs and made presentations about these designs in order to demo our ideas to the client

### Demo

- Demo the framework of the design to the client.
  - In our first demo of our design, our client indicates some weakness of our design and gave use many great advices
- Improve the design and make a ideal outlook of the design
  - We improved our design with the advice from the client and add some new ideas into the new design
- Repeat the above 2 step until the client is satisfied
  - This seems like a testing step. And we repeat this part for 2 times.

### Setup(program)

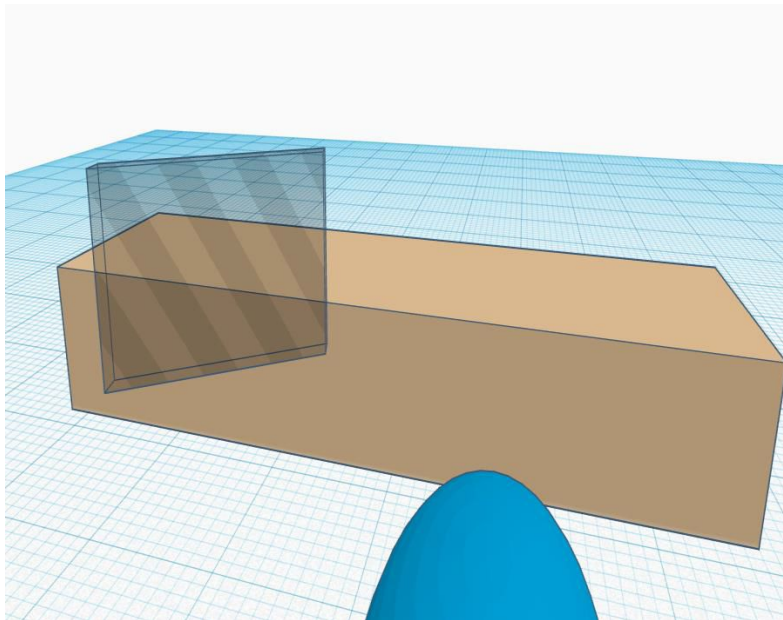
- Download the Unity and watch the tutorials online
  - Most of the tutorials that we used are on the Unity's official website
- Try to do some simple applications to familiar the operation of Unity.
  - In this part, we made several 2D UIs and simple games.
- Connect the Virtual Reality machine to the computer and make sure it can work.
  - Connect the headset with the computer and run the existing programs to know if the connecting is correct
- Start to work on the coding part of our design
  - Make the framework and a simple environment first
  - Filling the modules
  - Modify the framework and using the completed modules
  - Connect all the works

- Run our project on the VR headset and start the testing step

## Testing

- First, we execute the basic functions of our program
  - Moving
  - Select
  - Grab
  - Materialize the menu (During the above steps, we decided to materialize the menu board to so that to avoid the collision problem. )
- Then, we move to the complex methods
  - The functions in Menu Board
  - Tool belt
- Finally, execute the complete program to find if there exist any bugs or unsuitable areas
- Complete.

## 10. Appendix II



In this version, we try to make our UI interface moveable so that we can avoid the occlusion problem. Depending on the client's requirement, we add one feature, which is tool belt.

However, we have face the financial problem due to implement tool belt. The situation is that we need buy a tool kit if we want to show shape of tool belt, when the tool has the occlusion problem.

## 11. Literature Review

Our group was assigned a senior design project as VR environment user interface design. We were totally strange with this area and have to use a whole semester on research. At the beginning, I searched about what is VR and how it is look like in current world, after that we searched few already existing VR product and trying to analysis their advantages and disadvantages. Then I go over some tutorial about how to design interface in VR environment and fund out how is it different from normal interface in 2D environment and how to make it comfortable and useful. This semester we keep searching existing similar VR product and making comparison among them and compared with our work. One thing I want to mention is that during the design process, since I don't have budget and resources on experiencing all the VR product, watching VR game streaming became one of the most important resources. The idea of toolbelt was hinted from that as well.

The following are several papers or researches I thought useful for our VU UI design project.

The first paper was published in 1999 but it still has reference value, it is about design VRUI for Geographic information retrieval, we can see that although our goal is same but as technology developing the way and the process is totally different. We start with make sketches on paper and use 3d mod to represent in VR environment, however there is a drawback in such way since we can't imagine potential issue in VR environment such as occultation.

Second one is a research paper about VRUI in first person games, which is helpful since it's similar to our project. It gives the basic idea on what is VR what is UI and how is it different between 2D and 3D environment when designing, it also involved a concept called "VR UI Metaphors" which consists of I location type, UI correlation type and UI integration type, which is helpful when designing. Another useful example is 'out-of-Body', when within narrative user can leave body and change view from first person to third person view by flying above. This could

also be an useful idea on our project when user stuck into car don't know where he is or he wants to get a whole view of car, change the views.

Third paper is from IEEE and it is about locomotion interface which we were considering as our design but we were worrying about the potential issue such as collision and since our project does not too much movement so we abandon this idea. However, this paper shows that such design is acceptable.

It says" Our results show that, as in reality, the risk of future collision is accurately anticipated by participants, however with delay. We also show that collision avoidance trajectories formed in VR have common properties with real ones, with some quantitative differences in avoidance distances. ", which gives a positive exception on collision problem in VR environment.

Last one is directly related to or project and introduces an VR interface in car's virtual exhibition." User Experience approach system is chosen in order to help to understand the ideal experience of VRUI from user's perspective and needs, thus the designers and developers are able to develop the VRUI based on those factors. The expected results we could get from this research are; to design a VRUI application, we can use the same methods as creating the 2-dimension UI and using user's expectation as a tool to fulfill the user needs for VRUI." It offers a formal way of designing VR UI in a scientific way which I think is important and useful, even we don't have their resources we can learn a lot from them. I strongly recommend this paper as reference when designing VRUI especially for topic as our project.

To sum up, all those papers and researches are useful and can be regarded as guideline when designing VRUI. Especially the last one can be utilized if we have more time on this project to improving our current design by users' reactions and feedback.

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#### Citation

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