

# SKETCHING IN VIRTUAL REALITY FOR RAPID AND SITUATED IDEA GENERATION

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## ABSTRACT

We introduce a sketch-based 3D modeling system using Virtual Reality (VR) with a Head Mounted Display (HMD). The system enables users to sketch freely 3D objects in various colors, arrange and situate the objects in the environment and finally export the virtual objects into a 3D file for fabrication.

We evaluated the system in a small workshop with users, and the system was found to have a possibility for rapid ideation and for spatially conceptualizing ideas.

**Keywords:** 3D Sketching Interfaces, Virtual Reality, Digital Fabrication

## 1. INTRODUCTION

Current trends toward Digital Fabrication are changing the conventional scene in manufacturing. Consumers, who previously were able to buy only a few selections of the product mass manufactured by designers, are currently invited into the designing process with easier access to manufacturing technology such as CNC machines and 3D printers.

A growing number of fabrication laboratories represent this enthusiasm of the public on DIY and digital fabrication. However, most of the 3D modeling tools still remains too difficult for novice users to understand.

Especially, because most of the designing tools are screen based and require exact dimensioning for manufacturing. In contrast, in real world situations, everybody can understand size with the respect to

the products in their real environments. For instance, when buying new furniture, we keep comparing sizes and colors with those of existing furniture around rather than directly measuring exact size of it: a chair that matches well with my table on dining room, a desk that reaches until my belly button etc.

The aim of this research is to introduce 3D sketch tools in the virtual space with first-person-view where users can draw mesh lines with respect to their body measure and surrounding products in the virtual environment. As such, users are able to print directly products with the desired size without having to measure every side of the objects.

## 2. RELATED WORK

Finding easier ways of creating 3D objects has been an intriguing research area both in industrial design and computer science. Our system builds upon the existing body of work that aims to design intuitive and situated 3D modeling systems using natural interaction.

### 2.1 SKETCH-BASED MODELING IN 3D SPACE

The Sketch Furniture project by Swedish design company FRONT (FRONT, 2006) is an early concept of designing objects in 3D space as an easier way of fabrication. Some of trained designers start to draw objects on the empty space and surrounding motion capture system quickly captures the trajectory of hand movement of designers to create 3D products on the observer's screen. Spatial Sketch introduced by the University of Tokyo (Willis et al. 2010)

focused on 3D sketching system in the real space with instance visual feedback on 2D display. Noting that 3D sketch lines are mostly used to describe an approximate shape of the object, the research came up with an algorithm to create a solid mesh out of few contour lines. However, the research indicated that designers actually produced better 3D objects without results shown up in 2D screen due to difficulty in an automatic spatial conversion of objects from 3D to 2D.

**2.2 SITUATED MODELING**

Parallel to the 3D sketching approach encouraging freedom of expression on 3D space, situated modeling approach builds 3D rendered copies of tangible primitive shapes attached with markers in the real space. Body Avatar (Yupeng Zhang, Teng Han, TEI 2013) and Situated modeling (Manfred Lau, Masaki Hirose, TEI 2012) either copy human-body gesture of the user or existing 3D object to create new shape of objects. Despite comparatively rapid in visualizing 3D object, Body Avatar reflects mirrored image of the user that is only effective in building a specific objects covering the user’s body, and Situated Modeling (Manfred Lau, Masaki Hirose, TEI 2012) used a keyboard and a food pedal for manipulation, preventing natural interaction of the user.

**3. 3D SKETCH IN VIRTUAL SPACE**

The proposed system provides VR based 3D sketching system with the first person view in the virtual space to offer immersive user experience in space.



Figure 1. First person view in the virtual space

**3.1 FIRST PERSON VIEW**

Screen based modeling tools suffer from the discrepancy in dimensional difference of designing space (3D) and displaying space (2D) undermined accuracy of the final product. The related work showed that drawing 3D sketches without any 2D display rather improved the result. Our system aims to provide 3D feedback with a Head Mounted Display to decrease discrepancy by combining designing space and displaying space into one integrated 3D space.

As a result, the first-person-view on the 3D sketch not only provides realistic, therefore, immersive experience, but also enables users to naturally create objects with respect to surrounding furniture and user’s body in same environment.

**3.2 SYSTEM**

The prototype system is built with the Unity 3D game engine, as shown in (Figure 2).

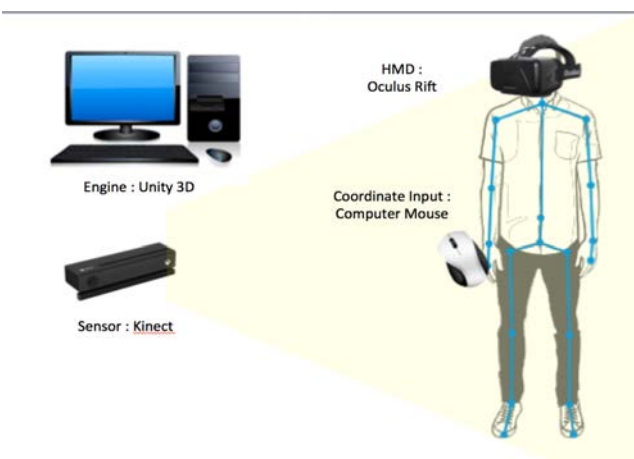


Figure 2. First person view in the virtual space

The application captures the 3D body position and gestures of the user with a Kinect V2 depth sensor. A Head Mounted Display (Oculus Rift) visualizes a 3D virtual living room. In that way, users can freely move around and design objects in the virtual space.

Users interact with the virtual environment using a standard wireless computer mouse. Early tests showed that clicking a mouse was easier to learn and more stable than the hand gestures recognized by the Kinect.

### 3.3 DRAWING IN 3D SPACE

We implemented a simple drawing system that resembles a 3D airbrush. Objects are made from many small and colored spheres. Objects can be created, moved around and exported to a 3D file.

A small sphere is visualized at the tip of the user's hand. When the left mouse button is pressed, this sphere is deposited in 3D space. When "dragging" the mouse in the 3D space, the spheres deposited along the trajectory form a line. Newly created spheres are linked as the children of the very first sphere to create a hierarchy so that they are easily editable in a group.

With the Scroll Button on the mouse, the color of the sphere can be changed. There is one special sphere that is drawn half transparent, for erasing spheres in the 3D space.



Figure 3. Drawing lines in 3D space to create objects

(Figure 3) shows the scene from the perspective of the user while sketching objects. The hands and arms of the user are depicted with lines and cubes as captured from the Kinect body skeleton.

When finish designing, users are able to move final object onto the desirable position to compare with the existing objects in the living room.

### 3.3 EXPORT TO 3D OBJECT FILE

Created objects are exported using the OBJ file format as a large collection of spheres. The OBJ file format is versatile and can, for instance, be used by Autodesk 123D Make to fabricate the shapes using 3D printers or laser cutters. (Figure 4) shows one example of such ways to fabricate a final product.

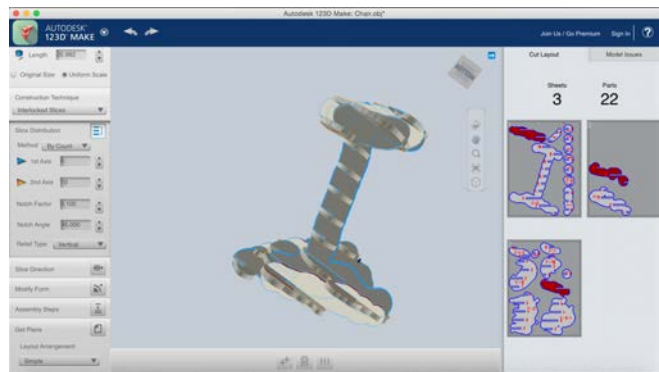


Figure 4. Simulation of an exported 3D object in Autodesk 123D for laser cutting

## 4. WORKSHOP

A small workshop session with three students (two female and one male) from an industrial design department was conducted to get early feedback on the system. The workshop was divided into two sessions: individual session and group session. The individual session started with a short explanation of the system and a few minutes of practice. Each of the participants was asked to model an existing product from a reference picture, and one product of his/her own design. After experiencing short designing stage, they went through group interview for 20 minutes to discuss the system. (Figure 5)



Figure 5. Participants in the group interview

### 4.1 OBSERVATION AND FEEDBACK

All of the participants agreed that they found the system interesting to sketch objects in the virtual space in which they felt absorbed to some extent to see themselves with body skeleton and instantly created objects on HMD. However, it was difficult to assure that system provides fully immersive experience because they were only able to move within only small range of area out of the whole

displayed area, due to the technical limitations of the Kinect sensor.

In the group discussion, all participants mentioned that they wanted more editing functions in the system such as rotation, scaling and movement. Instead of turning their body to the opposite side, they rather tried to rotate the object to draw lines on the other side. After realizing that the system did not provide rotating function, they tried to turn their bodies to the other side add lines, however, the system suddenly lost its accuracy as the Kinect only works properly with users facing the sensor.

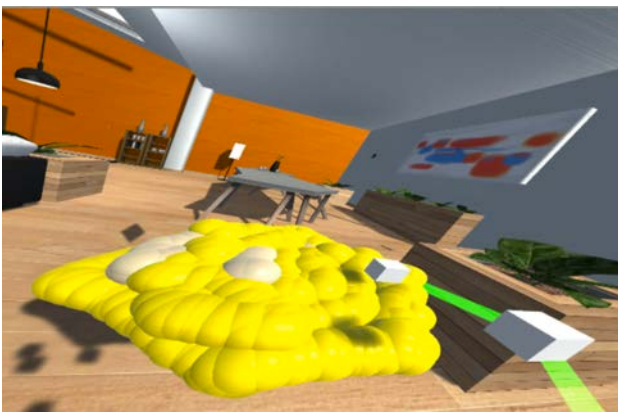


Figure 6. Users struggling to draw plane for a chair

Participants experienced difficulty drawing straight lines and surfaces only with spheres and suggested multiple types of primitives such as surfaces and cylinders and a snapping function for precision. (Figure 6)

## 5. DISCUSSION

Our prototype revealed some limitations of technology and implementation. However, the early tests with users provide confidence that our system has potential as a useful rapid designing tool for ideation in the 3D environment. Specifically because we observed users continuously determine optimal size according to their body and environment while

sketching shapes. This behavior is important for personalizing items and is not supported in the existing systems.

All participants were enthusiastic about the system, and that resulted in many suggestions for improvements and application ideas. For instance, when the system is used in designing furniture, users need to construct flat shapes such as planes or squares. Spatially arranging, rotating, scaling and duplicating objects was another common request as furniture often consists of repeated elements, such as the legs of a chair.

As to the system's applicability, participants noted its potential to be used an idea generation tool between a designers and non-designers. Difficulty in manipulating modeling system was known to be the main obstacle to their communication. Thus, rapid and intuitive visualization tool like this may help them to share ideas more easily.

Finally, collaborative multi-user designing scenario sharing the same environment will expand the use of this system as a collaborative visualization tool between users.

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