

An Immersive Modeling Workbench using a Combination of Two- and Three-Dimensional Interface

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Abstract

In this paper, described is a prototype of a novel hybrid 3-D object modeling system, NIME - NAIST Immersive Modeling Environment, which inherits the advantages of Basic concept of our system is to combine advantages of 2-D and 3-D modeling environments in one environment. By employing a slant rear-projection display, NIME integrates 2-D and 3-D modeling environments into a unified modeling space. On the surface of the display, NIME provides a user 2D GUI modeling interface. NIME also provides the 3D modeling environment with a field sequential stereoscopic imaging of objects and 6-DOF pen-type input device. A user can create models seamlessly switching between these two modeling environments.

Key words: Modeling, Virtual Reality, 3-D Interface

1. Introduction

In this paper, described is a prototype of a novel hybrid 3-D object modeling system, NIME - NAIST Immersive Modeling Environment, which inherits the advantages of both traditional 2-D GUI based modeling and 3-D immersive modeling environments.

3-D computer graphics (3D GG) [1], today, are widely used in various fields of visual expression, such as motion pictures, television, graphic design, presentations, and home video games. Since computers have advanced fast enough to render various complex shapes in a small amount of time, 3-D modeling methods that can efficiently model various complex shapes are needed.

In general, 3-D CG software for 3-D modeling use traditional WIMP (Windows, Icon, Menu and Pointers) interface, which uses a CRT monitor and a mouse, a 2-D input device [2,3]. In these modeling environment which utilize 2-D display surface, input degree of freedom which users can simultaneously control is limited to just one or two. This enables users to design objects accurately and precisely. However, as 3-D objects are designed using 2-D input devices, a mental mapping between 2-D input space and 3-D modeling spaces is used in users' cognition. Thus, it is possible to assume that the mental workload of controlling 3-D object using 2-D input device is relatively high compared to that of 3-

D direct manipulation.

In such an environment, a 3-D operation must be decomposed into a combination of 2-D operations, which is not intuitive [4]. Moreover, a lack of depth perception makes it difficult for user's to understand objects' shape and their spatial relationship [5].

In order to overcome these problems, Virtual Reality (VR) technologies, which typically use a head mounted display or 3-D mice, are used in several experimental 3-D modeling systems. These systems are called immersive modelers, as users of such systems immersed in a 3-D environment where a user can directly manipulate 3-D objects [4-12].

3-D object modeling using immersive modelers have the following advantages.

- 1) Objects can be displayed stereoscopically with depth perception and motion parallax. Therefore, the shape of complex objects can be easily understood.
- 2) By using input devices with three DOF or more, modeling objects can be directly manipulated or altered in 3-D space with intuitive manner. There is no need to perform mental mapping between 2-D input space and 3-D working space.

However, it is also known that humans are not good at simultaneously controlling multiple degrees of freedom and are not good at precise or accurate operation in 3-D space. This results in difficulties of performing accurate or precise design operation in immersive modelers.

Several methods to improve designing performance or accuracy in immersive modelers are reported [13-16]. For example, force or tactile feedback, which limits inputs DOF, is used in several systems. Other uses grid or other constraints or collision detection or avoidance, which limits the degree of freedom in operation when objects interfere with other objects [6].

However, posing constraints does not always provide as good performance as it may get when used in 2D environment. Also, it is known that typical force or tactile feedback device limits the user's workspace or needs large mechanical structure around users

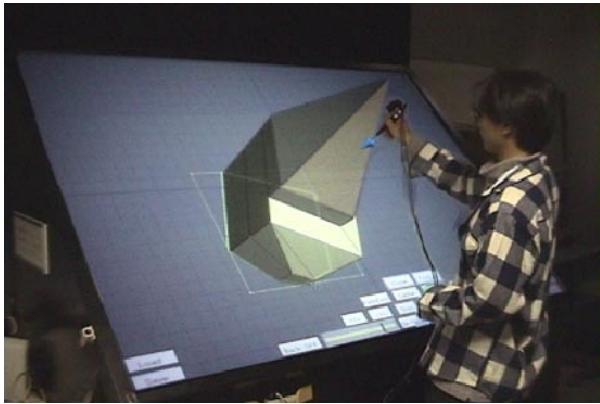


Figure 1: A scene of modeling in NIME

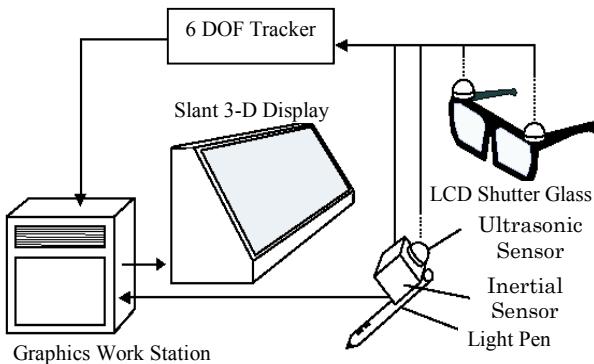


Figure 2: System Configuration of NIME

workspace.

Therefore, 2-D and 3-D environment has its own merits and demerits. It is more reasonable to combine both 2-D and 3-D environment so that a user can gain benefit of both environment.

In this paper, we propose to combine these two modes of operation seamlessly in single modeling application. In particular, we employ slant 3-D display of which surface can be used as drawing table and still the user can view screen stereoscopically with motion tracking stereo. Basic concept of our system is to combine advantages of these 2-D and 3-D modeling environments in one environment.

In the following sections, the system's overview, user interface design for modeling operation, examples of modeling operation, and discussion about the feasibility of proposed methods are described respectively

2. NIME System's Overview

Figure 1 is a picture of a user using the system. A user wears LCD shuttered stereo glasses and holds a 3-D light-pen-type input device. A modeling object is displayed in viewpoint tracking stereoscopic display. A user can have not only binocular parallax but also motion parallax when viewing the objects.

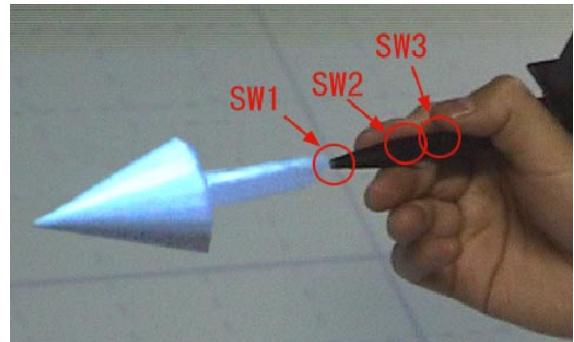


Figure 3: Pen-type input device with 3 switches

2.1 System's Configuration

Figure 2 illustrates the system's configuration. By employing a slant rear-projection display, NIME integrates 2-D and 3-D modeling environments into a unified modeling space. On the surface of the display, NIME provides a user 2D GUI modeling interface. NIME also provides the 3D modeling environment with a field sequential stereoscopic imaging of objects and 6-DOF pen-type input device. Therefore, a user can create models seamlessly switching between these two modeling environments.

Unlike the conventional 3D CG software systems, which display the projected images of manipulation targets, NIME provides a user the 2D modeling environment by showing the intersection of targets and the display surface on the screen. By showing both stereoscopically displayed object and its intersection all the time, a user can create objects seamlessly either in 2D or 3D modeling environments without any operation to switch one modeling environment to another.

2.2 Input Device

A 6-DOF pen-type input device (Fig. 3) is developed and used in this system. The device is a combination of a light pen, an inertial sensor, and an ultrasonic sensor. This pen-type input device can be used in both 2D and 3D modeling environments with the 3 switches arranged at the tip and the side part. By calculating the distance between the display surface and the tip of the pen-type input device, NIME detects which modeling environment the user intends to use. When the distance is within 5 mm, the user's operation is considered as for the 2D modeling environment and a dot cursor is shown according to a series of input from the light pen. On the contrary, when the distance is beyond 5 mm, it is considered as for the 3D modeling environment and an arrowhead cursor is shown according to a series of input from the inertial sensor and the ultrasonic sensor.

Figure 3 also shows the arrowhead cursor, which is used in 3-D modeling environment. By showing arrowhead cursor, a user can see if he is in 3-D modeling mode or not. An arrowhead cursor also helps user to converge his or her eyes to see stereoscopically displayed objects,

because it has consistent accommodation and convergence with other 3-D objects displayed on the screen.

Forsberg et al. [17] build similar system, but their system does not allow users to perform modeling in 3-D environment. In their system, modeling operation is carried out in 2-D environment and 3-D environment is mainly used to display created shapes on a field sequential stereoscopic display.

3. Modeling Objects with Two- and Three Interface

In NIME, a user can perform a number of modeling operations in both 2D and 3D environments according to the nature of each operation.

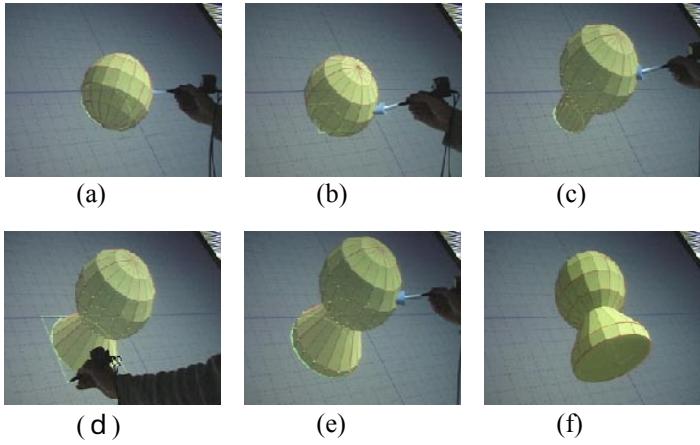


Figure 6: An example of “extruding intersection”

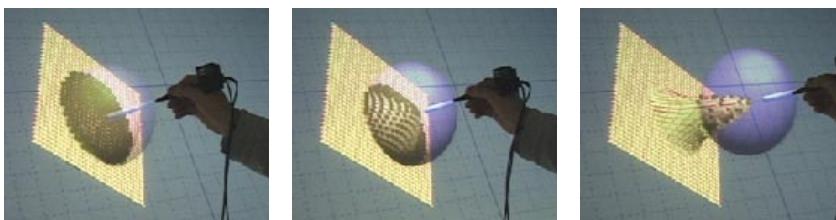


Figure 7: Shape deformation using “virtual magnet”

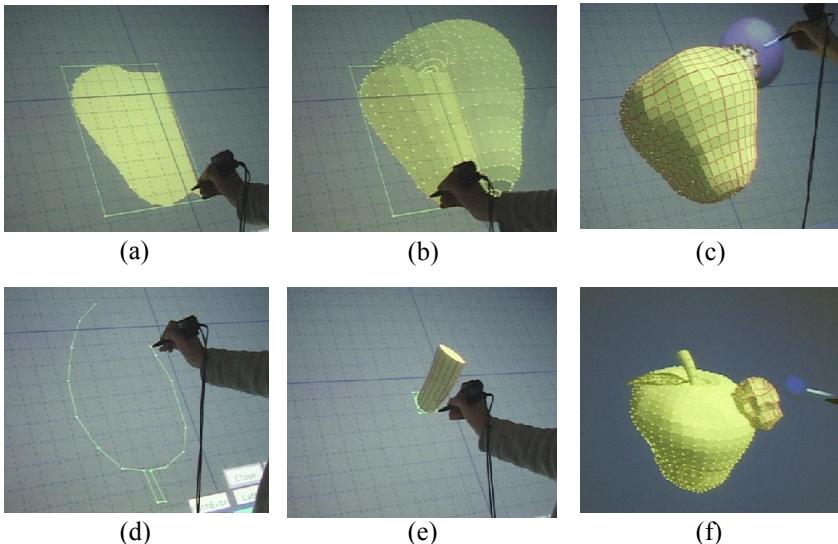


Figure 8: An example of modeling an apple

clicking and dragging handle of intersection (Fig. 6 (d)).

- (4) Then, a user can repeat extrusion by pulling up the object (Fig. 6 (e))
- (5) Finally, to stop extrusion and finalize the modification, a user pushes the menu button again.

Users can move the selected points or vertices of object both in 2-D and 3-D modeling environments. When users move the pen-type input device in 2-D modeling environment, the selected points translate only on the 2-

D plane. When in 3-D modeling environment, the selected points translate freely in 3-D direction.

The “virtual magnet” is used when a user wants to give the object smooth gradation. An example of using “virtual magnet” is shown in Figure 7. When a user selects “virtual magnet”, the arrowhead of the cursor changes to a spherical head, which shows the area of influence of “virtual magnet”. A user can modify the object by moving the pen-type input device. Vertices of the objects are attracted to virtual magnet and objects’ shape is modified as shown in Fig. 7. In this example, a flat surface is modified by pulling central part of plane making shape like a mountain.

The “Boolean operation” is implemented to perform Boolean operation among objects in 3-D modeling environment. Logical “and”, “or”, and “exclusive or” operations are prepared. These operation enables a user to combine multiple objects created by NIME system. The result of operations is easy to understand, because the operations are performed in 3-D environment and it becomes easier for a user to understand the relationship between objects

3.3 An example of Modeling

In order to discuss feasibility of the proposed modeling method, the modeling process of an apple is shown in Figure 8.

- (1) First, the 2D plane shape, which is the cross section of an apple, is created in 2D modeling environment. (Fig. 8 (a))
- (2) By revolving the 2D plane shape, the body of an apple is created. (Fig. 8 (b))
- (3) The “virtual magnet” operation is performed to give the body some natural distortion or bumps. (Fig. 8 (c))
- (4) A leaf is created as 2D plane shape in 2-D modeling environment and bended in 3-D modeling environment using “virtual magnet”. (Fig. 8 (d))
- (5) Beginning with a circle in 2-D plane, repeatedly applying “direct extrude” in 3-D environment and editing the intersection create a stem of an apple.
- (6) Each object is arranged at appropriate position in order to apply “Boolean operation”, so that objects are unified into a single apple model.

Figure 9 shows the final rendered image of the apple

created in NIME. At this moment, an attribute to polygons of an object surface for rendering, such as colors etc., cannot be given in NIME system. Therefore, external modeler is used for final touch up of the objects such as coloring and texture mapping.

4. Discussion

Through the modeling of an apple, the following characteristics of the proposed method are confirmed.

- (1) 2-D editing surface where a user can enjoy merit of 2-D modeling is embedded in 3-D environment.
- (2) A user can enjoy merits of both 2-D modeling environment and 3-D modeling environment while a user performs modeling without explicitly switching operational mode.

In this prototype system, a slant display is used. The surface of the display successfully provided a user a physical drawing surface, which constraints the users controllable degrees of freedom and helps their easy free hand drawing on the surface. This is mainly due to the following two reasons. Firstly, a pen type input device has an appropriate friction against the display surface and provided users an appropriate tactile and force feedback. Secondly, a slanted display created an appropriate drawing surface just like a drafting table. As a result, 2-D drawing in this system is found relatively natural and easy.

The switching between 2-D modeling and 3-D modeling in this system was implicitly performed based on the modeling command user performs and 3-D position of the pen type input device. A user can smoothly work on modeling without explicitly switching modeling modes. However, it is found that a user sometimes confused, when he is not familiar with the modeling operation implemented in this system. In other words, a user has to know which modeling operation is performed in 3-D



Figure 9: A photo-realistic rendered apple

mode and which in 2-D mode. This caused some modeling difficulties, when a novice user tests the system.

5. Summary

We have built a prototype of an immersive modeling system which combines 2-D and 3-D GUI. The system consists of a large slant rear projector and 3-D light -pen type input device. A user can seamlessly combine 2-D and 3-D operation to model objects. The feasibility of the method is discussed based on Informal user study. The study suggests that the system is easy to use for those who have an introductory knowledge of computer graphics. However there are some difficulties in using NIME, when a user first timers of CG modeling.

For future study, we are planning to conduct more detailed study on usability of the system. At the same time, the system will be expanded to accommodate more useful operations such as giving an objects' color and so on.

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