AN APPROACH TO 3D CONCEPTUAL MODELING

Using Spatial Input Device

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Abstract. This article presents a 3D user interface required by the development of conceptual modeling. This 3D user interface provides a new structure for solving the problems of difficult interface operations and complicated commands due to the application of CAD 2D interface for controlling 3D environment. The 3D user interface integrates the controlling actions of “seeing – moving –seeing” while designers are operating CAD (Schön and Wiggins, 1992). Simple gestures are used to control the operations instead. The interface also provides a spatial positioning method which helps designers to eliminate the commands of converting a coordinate axis. The study aims to discuss the provision of more intuitively interactive control through CAD so as to fulfil the needs of designers. In our practices and experiments, a pair of LED gloves equipped with two CCD cameras for capturing is used to sense the motions of hands and positions in 3D. In addition, circuit design is applied to convert the motions of hands including selecting, browsing, zoom in / zoom out and rotating to LED switches in different colours so as to identify images.

1. Introduction

Conceptual modeling serves as a stage full of active creativity in the process of architecture design. In the stage of conceptual design, designers usually develop models in various scales in order to provide visual thinking for further creations and modifications on the original design concept. In traditional architecture design, card papers, clay, gypsum or foam are used to form a model. Here comes a problem. The development of such forms is limited to the characteristics of modeling materials used. However, the existing CAD system has strong modeling function without being limited by the characteristics of practical materials used. The CAD system also has the
functions of direct zoom in / zoom out and viewpoint adjustment for the convenience of designers’ visual thinking. The existing CAD system is still hard to understand and less intuitive. It lacks quick and direct interactions for developing forms. The CAD system is still unable to fulfill the requirements for early design and development (the original configurations of CAD are for engineering graphics instead of the interface required by conceptual modeling).

Since the beginning of Sutherland’s Sketchpad Ph.D. thesis (Sutherland, 1963), this system allows users to make 2D sketches like arcs and lines by using optical pens. Afterwards, it has been a long story to develop the computer graphic system and the interactive system of manual 2D graphics for designers (Kato, 1982; Lenkins, 1993). The above-mentioned research and development are all within the extent of 2D graphics. The applications of 3D graphics did not fully start until the nineties. Tools for forming 3D sketches (Pugh, 1992; Eggli, 1995) were developed during that period. In the evolution of computer graphic capability, the input device used by designers for interacting with computer is maintained at the level of 2D mouse and keyboard input. As to 3D graphics, it is worked with computation plus Z-axis control. Users can only create simple 3D geometric objects (Zeleznik, 1996; Lipson, 1997) and further to simple free forms (Igarishi, 1999; Karpenko, 2002). However, the extra control of Z-axis is not intuitive at all.

During the period of 3D computer graphic development, the technology of virtual reality (VR) was also developed. VR technology facilitates the development of the operations between physical and virtual space. Through the discussions of HCI (Human Computer Interface / Interaction), possible interactions between design behavior and human computer interface have been developed. For example, IDEATE projects (Gribau and Hennessey, 2000) and Gesture Modeling project (Mark and Ariel, 2001) have developed a hand-simulating clay modeling method. Besides, approaches such as 3D responsive workbench system (Schkolne, 2000), 3D SketchMaker project (Pratini, 2001) and Free Hand Form Generation (Diniz, 2003) allow free hand controlling of profile so as to generate surface. These approaches are developed in a self-defined 3D environment. These systems simply provide a single generation method which does not sufficiently support complete control functions for architecture designers.

Though the existing CAD software (like MAYA and MAX) has been designed with complete 3D manipulating functions for a long time, it lacks a 3D input device ideally working with 3D software. The development of conceptual modeling is still at its preliminary stage. An input device under a comprehensive operational environment and with complete modeling functions for designers has not been provided yet. Therefore, the study develops new spatial input interface under the environment provided by the existing CAD system so as to improve the poor intuition of interface and
retard interactive process. Hopefully, an interface more suitable for designers can be provided.

2. The Loads of Human Computer Interface

It is not popular applying CAD to develop conceptual design even if the existing CAD software had an amazing modelling function. This is because it requires great efforts in the operations of interface while applying CAD to develop conceptual modelling. Meanwhile, designers also bear great loads of planning how to operate the interface, which weakens the attention to form development. The biggest problem comes from users’ being forced to use 2D-interface input device operating fixed points under a 3D environment. Poor input device results in tough designing control.

The human computer interface is connected with a computer by way of programming which provides an operational interface for people to use. However, knowledge load will be burdened in human mind if the operational approaches are different from the way human mind works. When the gap between human mind and an operational approach becomes greater, complicated and difficult operations may occur to users. Such condition is called “non-intuition” (Figure 1).

![Figure 1. The framework of human computer interface](image)

Design is a process of “seeing-moving-seeing” (Schön and Wiggins, 1992). Designers develop forms in the process of “seeing-moving-seeing”. Under traditional human computer interface with the combination of a mouse and a keyboard (a keyboard controls character input and access keys while a mouse controls 2D directions), designers have to make plane coordinate control first and then the vertical coordinate control so as to achieve spatial moving before controlling the moving of spatial positions. Designers also have to make
controls of moving, rotating and zoom in / zoom out before completing “seeing”.

Such system has a serious problem in operational sequences. The operation of commands happens before designers’ modelling process, which results in interruptions of process by command operations. The development of conceptual modelling under such an interface is only a test on user’s ability in transforming spatial concept into commands while creating. Other than that, such development is not meaningful to design itself. Consequently, the study re-establishes a new spatial input interface and attempts to improve the interactions between designers and computer (Figure 2).

![Diagram of CAD interface](image)

*Figure 2. Sequence of operation by traditional CAD interface*

### 3. The Spatial Input Device

The spatial input device allows designers standing in front of a large screen directly analogizing a position in physical space to a spatial cursor position under a MAYA environment. Designers can also use several simple gestures directly manipulating viewpoint and mouse-selected functions. Apart from the above, the pre-configurations of MAYA interface are kept as usual.
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3.1. THE PROCESS OF SYSTEM

The interactive pattern of the system combines two cameras and a pair of LED gloves. For improving the interruptions of modeling thinking caused by the process of commands using the traditional interface, the system takes the advantage of gestural spatial interface to allow users directly manipulating spatial positioning and viewpoint without complicated process of commands. The circuit design of LED gloves is used to analyze gestures and LED colors will change accordingly. Afterwards, the automatic process from Visual C++ programming, image capturing, LED color recognition, data computation to MEL commands will implement under the MAYA environment which transforms the process of commands into automatic program control. Therefore, the process of design will not be influenced (Figure 4).
Consider how to modeling

3. IMPLEMENTATION

The development of the interface includes the application of software and production of hardware. As to software, there are MAYA 7.0, Visual C++, MIL (Matrox Imaging Library) as well as MEL (Maya Embedded Language). As to hardware, there are one PC, two SHARP 1/3” CCD (Charge Coupled Device) cameras, two LED gloves and one Matrox-CronsPlus board. The practice is divided into four phases.
3.1.1. Early Test for Technique
Test RGB values of light points recognized by using webcam and Lua program and apply the coordinate values of light points tracked to sketches (Figure 6). The test shows the limitations on the speed of image capture, resolution and image quality in addition to the lack of 3D support. Therefore, high-quality system will be planned to overcome these limitations in the next phase.

3.1.2. Software and Hardware Planning
The system is set up in an environment with a large screen and two CCD cameras facing towards a user. The system is placed parallel so as to detect a user’s gestures and movements. The system is connected with a desktop computer which is equipped with an image capture device (Matrox-Cronos Plus) to receive the messages coming from cameras. Then, MIL(Matrox Imaging Library) and MEL (Maya Embedded Language) can be applied together to MAYA software through Visual C++. 
3.1.3. Image Recognition and Conversion of Spatial Positions
Place one CCD camera at a distance of 5.5 cm from the other. Define the valid range as that being detected by both cameras. Through the connection of CronosPlus board, use MIL to set the functions detecting the images derived from both cameras under Visual C++ operational environment. Then, recognize LED light point coordinates (Figure 8) based on RGB values. 3D coordinates against light points in the execution of program can be obtained by establishing an equation (Figure 9) in connection with the relative distance and depth between two light points.

![Software architecture](image)

*Figure 7. Software architecture*

![Simultaneously recognize the positions of light points shown from the two cameras](image)

*Figure 8. Simultaneously recognize the positions of light points shown from the two cameras*
3.1.4. Increase of Interactive Control

In this stage, LED in different colors will be activated by the circuits of LED gloves while sensing the gestures of selection, browsing, zoom in / zoom out, rotation and movement (Figure 10). LED colors are recognized through images which generate correspondent MEL commands for further execution under a 3D environment.

![Figure 10. Using gesture to manipulate functions of select position, zoom in/zoom out and rotation](image)

The above-mentioned stage is still in process. The part of executing MIL commands by connecting with MAYA has not been finished yet. The circuit functions for selecting and browsing have been put into practice so far. The selection function is defined as the movement when the index finger and thumb get closer to each other while the browsing function is defined as when fingers do not intentionally show strength according to the circuit design. Then, the circuit switching can be achieved through the combination of reek switch, magnet and two-color LED (as shown in Figure 11).
4. Conclusion

Though this study has not been completely finished yet, some practical functions have been implemented during the process of the study, for example, image recognition. The precision of spatial coordinates is acceptable. However, the precision decreases when the detecting distance increases. As to gesture interactions, the results of gesture signal switching via circuits are good. The switch control works very clearly which leads to easy image recognition. After the implementation is finished, further user tests will be conducted. Discussions will also be made on if the improved interface is able to generate more possibilities in forms than the traditional interface did.

Adding a new interface in MAYA will be useful for implementation. MAYA will become more comprehensive which can be directly applied to design at different stages. The spatial input operation contributes to an easy learning for interface operation. The communications between designers and computer are drawn nearer. The whole set of such equipment only costs 400 US dollars. Hopefully our further study may enable the computer for a more automatic execution so that the designers may concentrate more on creativity rather than technical steps.

References


