

Chapter 5 Conclusions and Future Works

5.1. Conclusion

In the past, 2D Visualized debuggers have the problems of FOV and low usability when the amount of visualization information scales up. In this thesis, we describe a 3D debugging information visualizer called DIVINE. We have presented the object-oriented and device-independent 3D user interface framework in DIVINE. The main contributions of the thesis are summarized as follows:

- DIVINE extends the visualized debugger into 3D environment that can overcome the limitation in 2D display. While visualizing large amount of data structures, 3D provides better FOV and another dimension for rendering and displaying information.
- The device-independent framework provides end-users flexibility to use various devices to interact with the visualized metaphors but in the meantime, impose no efforts to VM programmers.
- Using the head-mounted display with a 3-DOF tracker provide the user sense of presence in 3D environment.
- Using the data glove with a 6-DOF tracker provides a more intuitive user interface that is similar with the operation of human hand.

5.2. Future Works

Based on the device-independent 3D user interface and visualization metaphors in DIVINE, we hope to construct DIVINE as a general purpose 3D visualized debugger. Furthermore, we plan to build a general purpose program visualizer that consists of DIVINE and HILCADT. With the general-purpose program visualizer, problems of program comprehension and difficulties of code maintenance will be overcome. To achieve the goal, there are several works need to be done in the future.

5.2.1. Navigation Panel

Navigation is essential in visualization, especially a large amount of visualized metaphors occur in the visualization application. For example, a user may want to pick one of the 3D objects out of user's reach. There have been some researches, such as physical locomotion techniques, steering techniques, go-go techniques [31] and WIM [33] (see section 2.3.3), try to overcome the problems of navigation in a wide virtual environment or interaction with objects far away.

In these techniques above, users often travel around the environment. However, most developers sit or stand in place without moving around while debugging. The 3D user interface of DIVINE implemented in the thesis can only change the position of view point by the keyboard or mouse, which is not an intuitive way to navigate. For this reason, we propose the concept of "navigation panel." While users want to move

in some direction, they only need to move their hand on the virtual panel in corresponding moving direction. For example, the user's view point moves forward when the user touches the front part of the panel by his hand. For more effective movement, moving velocity can increase linearly or non-linearly according to the distance relative to the center of the panel. The technique thus can provide an intuitive and effective navigation control.

5.2.2. Two-Handed Manipulation

There is only one set of a hand tracker and a data glove used in current version of DIVINE. To provide various interaction and manipulation with visualized metaphors in the virtual environment, we plan to use two sets of data gloves and hand trackers in DIVINE. Two-handed manipulation is more intuitive and similar with the operations of human's hands. For example, a user may want to group a set of 3D objects by drawing a virtual rectangle area with both hands, rather than drawing a circle in the air with single hand. With only one set of data glove and hand tracker, interactions like grouping objects are more difficult and need extra operations.

5.2.3. Hardware Improvement

In DIVINE, we use lots of VR equipments, such as HMD, trackers, and data gloves. These non-traditional devices are still expensive and not so general in nowadays. Reviewing the progress of information technology, the development of

hardware is the most noticeable. Once killer applications appear in hardware, the effect caused by mass production will make the prices of the hardware drop down rapidly. With the device-independent framework, if there are more convenient devices used in 3D user interface in the future, DIVINE provides much flexibility for use various devices to interact with visualized metaphors.

Besides, more novel and efficient display techniques are under development. We can expect that the HMD will be as light as glasses with higher resolution and the trackers will be more precise and cheaper in price. Moreover, the data glove may provide force-feedback interactions while users touch objects in 3D environment. Wireless devices also provide more convenient movement. With these hardware progresses in the future, we believe that DIVINE will provide a more efficient debugging visualization environment.