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User-Interface Design of the Support System for Constructing Virtual Environment

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1 Introduction

VR-based training system has a number of advantages over the conventional training method by using real machines or real-size mockups. But since the VR-based training system is based on computer simulation method where the training environment should be prepared by programming the relevant software, the programmers' load for constructing the VR-based training system will be a serious problem to develop the system applicable for different kinds of training tasks. Therefore, it is necessary to develop the effective supporting system to construct such VR-based training system rather easily, in order to introduce VR-based training method in real working areas. In our previous research (Ishii 1998), a prototype design support system had been developed for constructing virtual training environments by which a trainee can disassemble/assemble machines by using human interface devices special for virtual reality. This system was developed with the purpose that even the novice users who have no knowledge about VR and the related programming could construct the system very easily. But through some experiments after the initial system development, it was found out that there were some insufficient parts in the prototype system, especially in the user interface. So, in the next step, we have improved the interface functions of the support system, by reflecting several requirements induced from the results of questionnaires given to the subjects participated in the evaluation experiments for the usability of the prototype support system. The effect of the improvement was then examined by conducting a new usability experiment. In this paper, the configuration of the design support system, how to improve the interface of the system, and experimental result of usability evaluation are described.

2 Design of Prototype System

To construct an effective training environment, it is desirable that the training instructor constructs the training environments. But most of the instructors have no knowledge about computer technologies such as programming. Therefore, we have assumed that the users of the design support system is the people who have no experience of computer programming, but can manipulate "WIMP interface" such as button and slide-bar with a mouse and a keyboard. We aimed at constructing the design support system by which users can construct virtual environment only by the guidance of Graphical User Interface (GUI), for the user to design the complete set of parameters that define the nature of virtual objects used in the VR-based training system. In this study, the user interface for setting the parameters is designed according to the follow aspects:

1. The structure of the menu should be designed based on the comprehensive procedure to construct a virtual environment naturally,
2. The buttons of the design support system should be designed with graphical icons by which users can easily imagine the function at first sight of the buttons, and

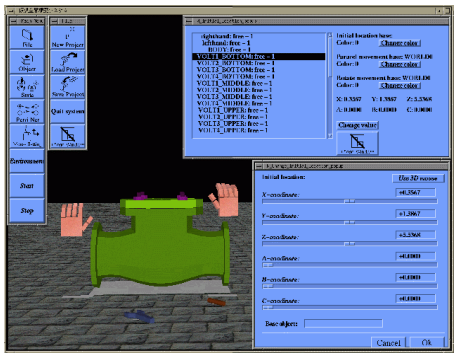

Figure 1. A snapshot of the prototype system.

3. The use of 3-Dimensional (3D) mouse should be restricted only for the both cases of setting 3D positioning of objects and changing the user viewpoint.

The developed interface for designing the parameters consists of 20 windows. Figure 1 shows the snapshot of the prototype design support system. For the details of the prototype system are described in the authors' preceding paper (Ishii 1998).

3 Usability Experiment to the Prototype System

To estimate the interface of the prototype system, a usability experiment has been conducted.

3.1 Method

In the experiment, two subjects (subject A and B) were asked to construct a simple interactive virtual environment by using the prototype system. The whole

process of the both subjects working to construct the VR-system was observed and the time necessary for constructing the virtual environment was measured. Moreover, after the experiment, questionnaires were given to the subjects about the quality of the design support system. The target virtual environment the subjects were asked to construct was such that a motor can start and stop its rotation by selecting a switch. The surface models of the target machine and textures were prepared beforehand with other applications. And prior to the experiment, guidance course of 30 minutes was allocated to the subjects, to explain how to use the prototype design support system. Both of the subjects had no experience of using the design support system although they were accustomed to using the 2-Dimensional (2D) mouse and the keyboard.

3.2 Experimental Result

Both of the subjects could construct the objective virtual environment correctly. The working times for the construction were 41 minutes (subject A) and 38 minutes (subject B). The results of the observation and the questionnaires given to the subjects are such as:

1. Use of 3D mouse is fit for pointing 3D locations in rather broad area, but it is not suited for pointing exactly at a certain point. Therefore, it takes much time for the users to master the 3D-mouse manipulation.
2. There are too many windows for setting the parameters. It is bothersome to open and close a number of windows many times,
3. The large buttons with large icons will hide the screen for viewing the image of the virtual environment,
4. The menu structure based on the construction procedure was perplexed when the virtual environment should be changed during the user work, and
5. There are too many parameters to be set.

Therefore, the interface function of the prototype is considered to be rather poor from the cognitive aspect to bundle the support system.

4 Improvement of the Interface

The result of the usability experiment to the prototype system revealed the insufficiencies of its human interface, and therefore, the cognitive task analysis were made to the interface work to improve its efficiency. The interface of the prototype design support system was improved based on the result of section 3.2. The individual improvement items conducted for the interface improvement are summarized as below:

1. The method for changing the sight direction and the one for setting the location of objects should be distinguished clearly, by separating the use of

2D and 3D mice. 3D mouse is used only for changing the sight direction, and a new interface for setting 3D location of objects is introduced by using only 2D mouse.

2. The layout of the buttons on the CRT screen should be reformed. The system functions which can be divided into the same category should be put together. With this alteration, the numbers of the windows for setting the information of the virtual environment would be reduced to about half as before.
3. The usage of icons should be limited as less as possible, except for the case when the users need not view the image of the virtual environment. The buttons with the text that explains the function of button were used in the improved system, rather than the buttons with icons used in the prototype.
4. The structure of the menu was reorganized by information-centered organization rather than initial procedure-based structure.
5. To reduce the number of the parameters to be set in constructing virtual environment, the parameters used many times are present by default values.

Figure2 shows a snapshot of improved design support system. The amount of the displayed information and located buttons on the window in Figure2 is the same as the window in Figure1. But the screen for viewing the image of the virtual environment on the window in Figure2 is larger than that in Figure1.

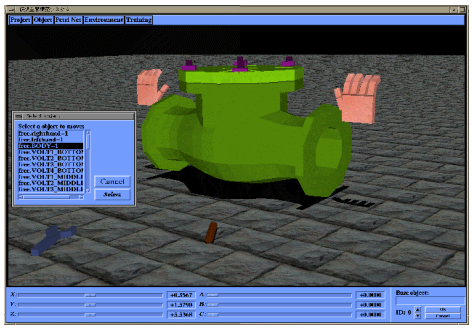

Figure 2. A snapshot of the improved system.

5 Usability Experiment to the Improved System

A new usability experiment has been conducted, in order to see the effect of interface improvement.

5.1 Method

The conditions of the usability experiment are the same as described in section3.1. But to avoid the influence that subjects become used to manipulate the design support system, the subjects of this experiment are different from the subjects of the former experiment. And both of the subjects (subject C and D) also had no experience of using the prototype design support system and they were also accustomed to using the 2D mouse and the keyboard.

5.2 Experimental Result and Discussion

Both of the subjects could construct the objective virtual environment correctly. The working times for the construction were 20 minutes (subject C) and 16 minutes (subject D). The virtual environment constructed with the improved design support system is the same as the environment constructed with the prototype system, but the working time was reduced as half as that of using the prototype system. The reason of why the reduced working time by the improved system was supported by the observed numbers of input manipulations of users to the system by the improved system. The reduction of input manipulations was because of the alteration of preparing the values that are used many times. From the result of the questionnaires, there were no opinion "It is difficult to point 3D location of objects", which is obtained at the prototype usability experiment. It seems that this improvement is caused by the alteration from the method with 3D mouse to the method with 2D mouse.

6 Conclusions

From the experience of the GUI improvement to the VR-based design support system, it was found that the working time for the users could be reduced to about half of that by poor design. As a conclusion of this study, the effect of cognitive design for the part of human interface is very large to reduce workload for doing the same work. The lessons from this study are summarized as follows:

(1) The whole input information need for the whole task fulfillment should be analyzed beforehand by cognitive task analysis, so that the input information be structured to reduce the user's handling number at interface, and

(2) The usage of input devices (in this case 2D mouse versus 3D mouse) should be selected based on their characteristics of their superiority or deficiency manipulating the input parameter.

7 References

Ishii, H., Tezuka, T. & Yoshikawa, H. (1998). A study on design support for constructing machine-maintenance training system by using virtual reality technology. *7th IFAC-MMS*, 389-394.