PHYSICAL TASK LEARNING SUPPORT SYSTEM VISUALIZING A VIRTUAL TEACHER BY MIXED REALITY

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Abstract: To support learning physical task, we have developed a system showing a CG virtual teacher in the real world by mixed reality technology. Most of existing physical task learning support systems do not show instructions in the real world. They do not instruct interactively in real time, either. The proposed system achieves these. Initial experiment of the effect of the location of the virtual teacher was also conducted.

1 INTRODUCTION

Research on supporting various tasks that utilizes VR or MR (Mixed Reality) technology has been actively conducted recently. Because it is known very effective to use actual equipment in the real environment for learning physical task, researches on supporting physical task learning in such environment using sensors and VR have been conducted (Watanuki, 2007)(Ohsaki, 2005).

There are also researches on utilizing VR technology for task learning or work support. For example, there have been systems for learning body movement (Yang, 2002)(Nakamura, 2003)(Honjou, 2005). These systems show a 3D CG teacher for a learner to follow its movement. Other examples are systems that show related information according to the places in the real world. There have been work support systems of this kind (Reiners, 1998)(Klinker, 2001).

MR is able to support tasks in the real world, and is able to realize user interfaces that are more adaptive to user behavior compared to VR (Bannai, 2003).

From these considerations, using MR is thought to be suitable for supporting physical task learning. Thus we have developed a task learning support system using MR It visualizes a virtual 3D teacher in the real world in front of a learner by MR, and is interactive to the learner's movement. In this paper, we also discuss places of presenting the virtual teacher.

Related research is described in Section 2. Proposal of a MR physical task learning support system is given in Section 3. Implementation of the system is described in Section 4. Preliminary experiment is given in Section 5. Conclusion can be found in Section 6.

2 RELATED RESEARCH

2.1 VR-based Task Learning Support

There have been various researches on VR-based skill / task learning support. In the case of the VR-based operation training system by Ohsaki et al., a virtual work environment is built in the virtual space (Ohsaki, 2005). VR-based dance training system by Nakamura et al. shows 3D dance examples in the virtual world (Nakamura, 2003). Sport skill acquisition support system by Honjo et al. shows examples in HMD (Honjou, 2005).

These VR-based learning support systems use the virtual world. The virtual world is useful because it can provide the environment that is difficult to realize in the real world. On the contrary, it is needed to reproduce the real world in the virtual world to represent physical objects. It is not easy to achieve (Bannai, 2003). MR technology has been applied to deal with this problem.

In the study of the presentation position for a body motion in a VR-based motion learning system, both a model motion and a participant motion were displayed in the same HMD screen (Kimura, 2007). In this condition, it is easier to follow to the motion

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when more axes between the model body and the participant body are aligned. Because the participant cannot see the real world in the condition, he/she cannot see his/her own body. It may not be realistic to learn body motion in this situation.

2.2 MR-based Task Support

The work support for instrument operation and the work support for design in industrial field have been researched using the MR. AR Power Plant Maintenance overlays task instruction to the place of maintenance through a HMD (Klinker, 2001). Space Design helps designing 3D objects that are projected on a desktop with a stylus pen (Fiorentino, 2002). As a collaborative work support between distant places, sharing an object and sharing the manipulations to the object between the places has been researched (Bannai, 2007).

In the MR-based task support, virtual objects are overlaid in the physical world. So task support using the physical equipment is possible. Gestural user interfaces are also easy to use (Bannai, 2003).

2.3 MR-based Task Learning Support

Different from the task support, information feedback to a learner is needed in the task learning support (Watanuki, 2007). There are few MR-based task learning support systems. Visualization of a task record in MR space is an example of a MR-based task learning support system. This proposes efficient task review by visualizing the manipulation record, position record, and the video of a target object together (Miyasa, 2006). However this is to support review of a task, not to support the task itself, and does not give information feedback in real time.

3 PROPOSAL

3.1 System Proposal

In this research, the motion of a task is presented by a 3D teacher model in front of a learner in the real world.

There are various elements for describing tasks. Some of them are the form, the position, the order, the rhythm, the spending time, and so on. This research deals with the form, the position, and the order. Pushing buttons on a desk in the predetermined order was chosen as the model task because this is simple and generic physical task.

3.2 Context-aware Presentation

Appropriate information feedback is important for effective and smooth task learning (Watanuki, 2007). In the conventional task learning by a real teacher, he/she observes a learner and makes intervention when the learner makes a mistake. To realize such interactive information feedback to the learner, sensing learning tasks or their progresses can be seen in VR based learning support systems (Watanuki, 2007)(Ohsaki, 2005)(Nakamura, 2003). This is applicable to the MR-based learning support systems. In our research, the learning tasks and their progresses are sensed as learner's motion and operation to the target objects by the motion tracking system. The teacher model is presented according to them. This realizes interactivity in the real world.

3.3 Teacher Model Presentation

The position and direction of the teacher model is known to be effective to the task understanding in VR-based systems (Fiorentino, 2002). Because the teacher model is presented over the real world in the MR condition, its position and direction are not less important than the VR condition. However, it has not been known yet. To investigate appropriate presentation of a teacher model, relative position between a learner and the teacher model was organized first in this section.

Let d be the distance between the model and the learner. Let θ1 be the angle between the front direction of the learner and the model. Let θ2 be the rotation angle of the model from the front (Figure 1).

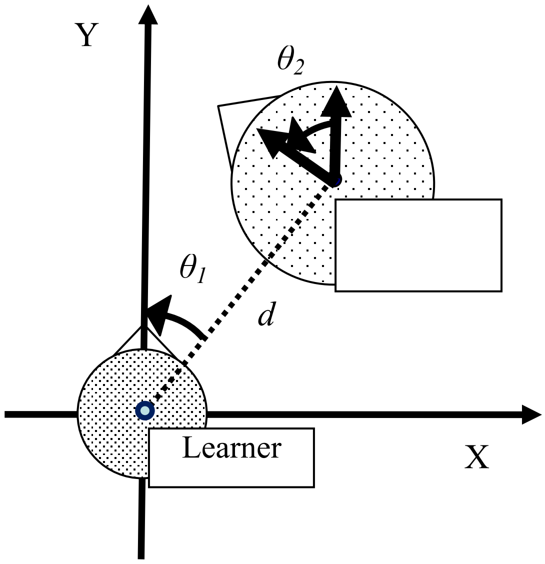

Figure 1: Teacher model presentation.

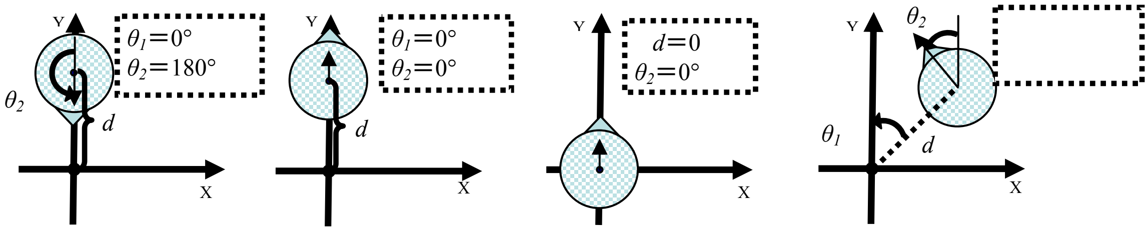

Figure 2: Examples of relative positions of the teacher model.

Then relative position between a learner and the teacher model can be represented by d, θ1, and θ2.
When presenting the teacher model, presenting the teacher model behind the learner is not realistic. Human horizontal view angle is about 200° at a maximum. From these, - 100° < θ1 < 100° is natural constraints (Kiyokawa, 2007). Here let height of presentation be the same as the height of the eyes of a learner. Examples of relative positions of the teacher model are shown in Figure 2. They include opposite direction, same direction, and same position.

4 SYSTEM

4.1 Configuration

The system configuration is shown in Figure 3. Three optical motion tracking cameras are placed above a desk. These cameras detect markers that are worn in the hand. Three markers that are at vertices of a small triangle are used as a hand tracking markers to know the hand direction stably. The teacher model is presented by a video see-through head mounted display. The size of the HMD is 640 x 480 pixels. The view angle of the HMD is H51°x V37°. A position sensor for the HMD is Polhemus FASTRAK. There are 5 buttons on the desktop. These buttons are simple push buttons and do not contain any sensor or mechanism. Pushing the buttons is generic example of physical task.

4.2 Use Scenario

The system architecture is shown in Figure 4. Scene of using the system and the learner's view are shown in Figure 5 and Figure 6, respectively.

Before the system starts, a learner wears the HMD on his/her head and the markers on his/her hand. When the system starts, it displays the teacher model overlaid to the physical space. The teacher model shows the physical motion of a task. In the physical space typically are physical objects to be handled. In the current example case of the system, they are 5 push buttons on a desk of approximately 12 cm in diameter. The learner can learn the physical task or the physical motion that the teacher model presents by watching it in front of the physical target objects.

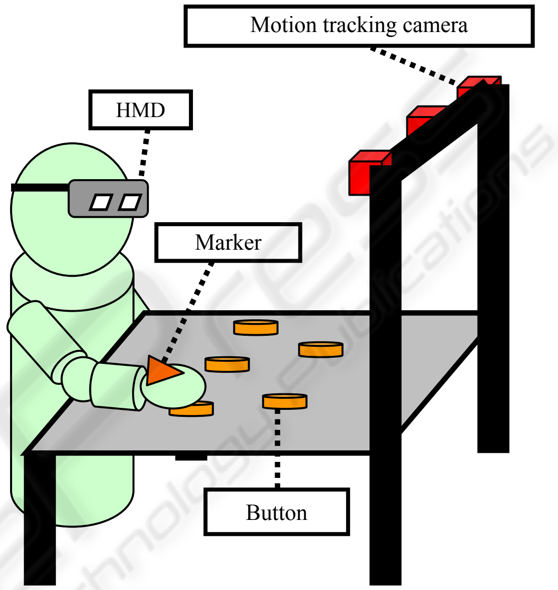

Figure 3: System configuration.

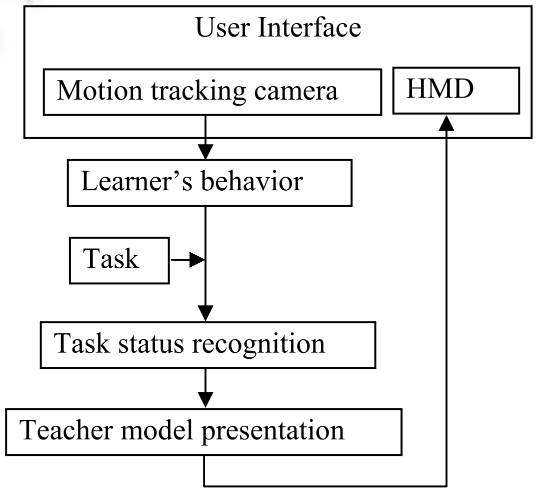

Figure 4: System architecture.

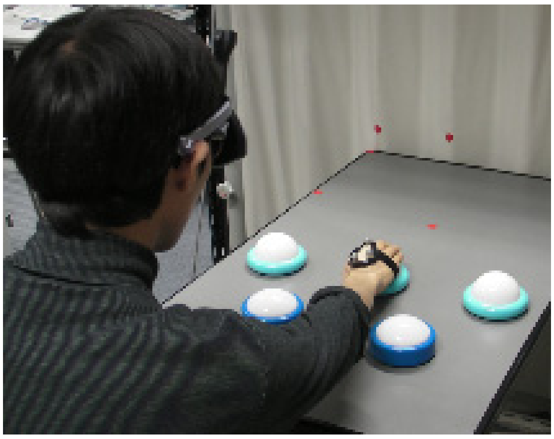

Figure 5: Using the system.

Figure 6: Learner's view.

The learner can learn by following the motion as shown in Figure 6. The motion to be learnt is given to the system in advance so that the system is able to recognize whether the learner's motion is correct or not. When the learner's motion is correct, the system continues to present the next motion. When the learner's motion is not correct, the system presents the same motion again. In the example, the position of the leaner's hand is tracked by the motion tracking cameras. It is checked that the learner pushed the same button the teacher model pushed in the example.

4.3 Appearance and Motion of the Teacher Model

To avoid effects of the teacher model appearance on the task performance, a plain cylindrical 3D model is used (Figure 7). The model is animated by the free software RokDeBone2 (RokDeBone2, 2010). The motion of the current system consists of a sequence of the motion units. Each motion unit which shows

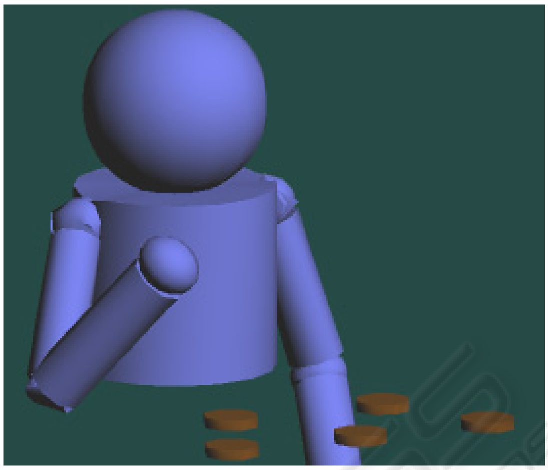

Figure 7: Appearance of the teacher model.

pushing each button was prepared in advance. Then the motion unit is combined in a sequence. Different task is produced by the different combination of the motion units.

5 PRELIMINARY EXPERIMENT OF THE TEACHER MODEL POSITION

5.1 Objective

This system can change the position of the teacher model, but which position is desirable to a learner is not known.

Because the position of the teacher model can be set freely and its variation is unlimited, we need to get a clue to the possible positions before elaborate experiment. So the objective of this preliminary experiment is to narrow down candidate positions.

5.2 Procedure

The teacher model was presented at various positions. Intuitive understandability of the motion was rated in 7-point scale by 2 participants. Total of 120 positions were evaluated where 3 conditions of d (0m, 1m, 2m), 7 conditions of $\theta 1$ (0°, ±30°, ±45°, ±60°), and 8 conditions of $\theta 2$ (0°, ±45°, ± 90 °, ± 135 °, 180°). Figure 8 shows these positions where the participant is located at the origin.

5.3 Result

The positions that were rated 4 or more out of 7 are shown in Figure 9. As for the distance d, many of

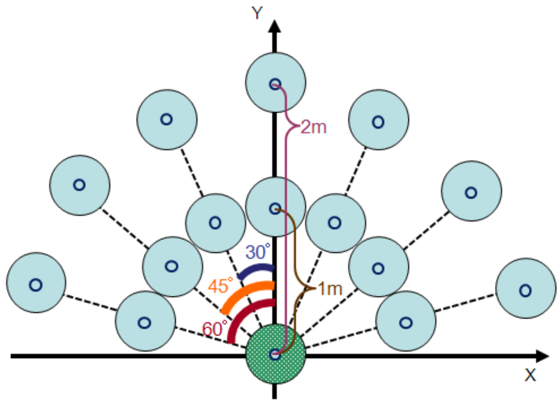

Figure 8: Evaluated positions in the preliminary experiment.

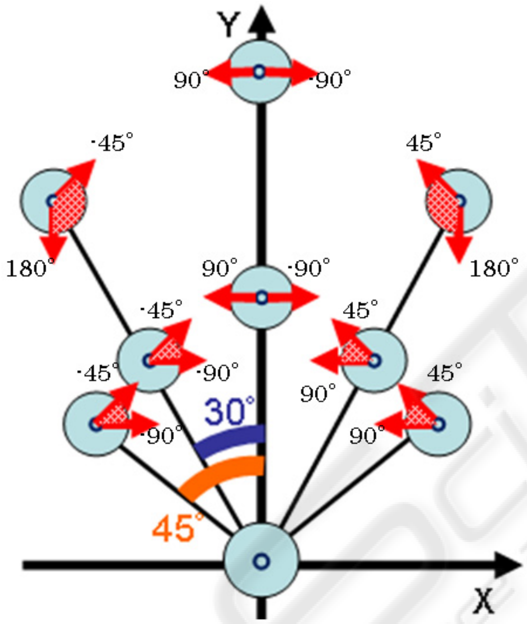

Figure 9: Highly evaluated positions.

them are near the participant. As for θ1, many of them are in front of the participant, but not exact front. As for θ2, side view of the teacher model seems to be preferred.

6 CONCLUSIONS

A physical task learning system that uses interactive MR teacher is proposed. It provides instruction in the real world which is different from VR-based systems. It also provides real time interactive support of a physical task by sensing the learner's motion. Visualization of a teacher model will be researched more in the future.

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