Training Archived Physical Skill through Immersive Virtual Environment

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Abstract. The basic of training physical skills is to imitate instructor's motion. Observation is the very first step to copy the motion of instructor when at the beginning of learning sports of artisanship. However, beginners face difficulties in imitating at the start since they do not have somesthetic image of the movement. In order to help learning physical skills, we propose Immersive virtual environment using head mounted display that indicates 3D motion of instructor super imposed on learner's body. By using this system, learners try to match its own form to instructor's 3D model to imitate instructor's motion from first person view in virtual environment. At the early stage of this research, we tried to transfer pitching skill in baseball. We evaluated the effectiveness of proposed system by measuring throwing distance.

Keywords: Skill transfer, Augmented Reality, Immersive virtual environment, Head mounted display.

1 Introduction

Training systems that transfer physical skills of experts are become more important as the trend of demographic composition changes by falling birth rate and aging. In industry, traditional arts, or sports, it makes training process more efficient if we can project one's somesthetic image to another by using virtual reality technology. In most cases, beginners do not have such somesthetic image so that they cannot mimic the motion of experts' effectively. Many researches had been done to develop the system using virtual reality technologies that support beginners to learn experts' motion for the application of artisanship. Most of them present experts' motion from the first person view of expert through head mounted display and those studies achieved to accelerate the learning speed of beginners.

On the contrary, in field of sporting activities, it is difficult to understand whole motion of instructors from the system that shows instructors motion from the first person view. Sport activities relatively require fullbody motion compared with

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artisanship. Thus this difficulty is caused by restricted viewing angle of first person view. Learners are not able to image whole movement of such fullbody motion.

In this study, we proposed to design a first person view learning system using head mounted display. The difference between conventional first person view physical skill learning systems is that proposed system allows learner to step away from first person view to third person view seamlessly. Additionally, 3D motion model of an instructor in proposed system is interactively triggered to play back according to the posture of the learner.

This paper first discusses related works (Section 2), followed by proposed methodology (Section 3). Then, we provide an overview and an implementation of a proposed training system in immersive virtual environment (Section 4). We prepared two different conditions of prototype interfaces and conducted exploratory experiments (Section 5). With these results, we discuss the design of integrated systems (Section 6).

2 Related Works

In this section, we introduce and discuss relevant researches on physical skill training using virtual reality technologies.

Nawahdah et al. proposed a system that interactively changes the viewpoint of learner and shows the motion of instructor in 3D virtual environment and suggested the system improves learning efficiency [1]. Anderson et al. Introduced the system that teaches full body motion by using augmented reality mirror and visualizes the difference between instructed motion and learners' motion. The system made a better performance in learning efficiency compared with conventional video learning [2]. Rector et al. developed a system to teach the motion of yoga. Their system captures the motion of learner by Kinect and feedback the difference between instructors posture by audio interface [3]. In terms of auditory feedback, Kapur et al. suggested that it is possible to support understanding the motion of dance by audio interface [4]. Chua et al. implemented virtual reality learning system of Tai Chi. The system displays both captured learner's and expert's motion in 3D virtual environment. Learner is able to compare the difference from an expert visually. Nevertheless, they reported that the system did not make a significant improvement to learn the exact motion from third person view compared with conventional method [5]. Yang et al. introduced a ghost metaphor that super imposes the instructor's motion to learner's body in computer graphics. The system aimed to support learner to subjectively understand the motion from third person view. The system was named "Just Follow Me" and they improved the learning efficacy in calligraphy learning by the system [6]. Hiyama et al. developed a wearable learning system that enables to experience multimodal information of an expert from first person view (Fig. 1). and improved the skill of making Japanese traditional papermaking [7].

Aforementioned works focused on developing the system that compare and visualize the difference of the motion between expert and learner. These works made successful achievements in transferring physical skills like artisanship, which does not

includes locomotion, by displaying the information from first person view using virtual reality technologies. However, the effective system that supports learning dynamic motion in sport activities from first person view is yet to be examined.

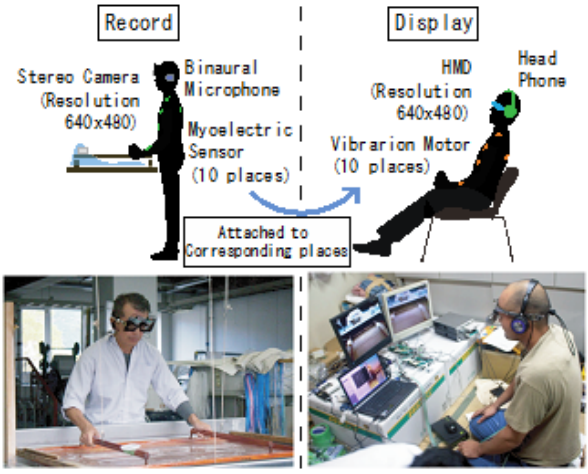

Fig. 1. Wearable recording system and displaying system [7]

3 Methodology

Tracing the instructor's motion displayed 3D through head mounted display is an effective use of immersive virtual environment. Although, it is difficult to train physical skills include fullbody motion or locomotion through such system. In this section we propose a method to apply this kind of system to training physical skills in sport activities. The proposed system designed to allow learner to step away from first person view to third person view seamlessly to overcome abovementioned problem.

There is one additional problem that makes it difficult to follow instructor's motion is the quickness of the motion in sport activities. In order to solve this problem, we adopted key posture method. Key posture method helps learner to mimic a set of movements step by step (Fig. 2). By using this method, learner is able to imitate the instructor's form interactively in accordance with her/his learning speed.

As an example application for sport activity we chose pitching motion in baseball. Instructor's pitching motion is captured by Microsoft Kinect and visualized as 3D model illustrated in Fig. 3. We divided pitching motion into 17 steps. Instructor's 3D motion model is displayed as red model and learner's 3D body is displayed as white model. While learner is trying to mimic the posture of instructor's body, body parts of learner's, which successfully matched to instructor's posture, turn to change its color to yellow (Fig. 4). Certain number of learner's body parts turn to yellow, next key posture is presented to learner.

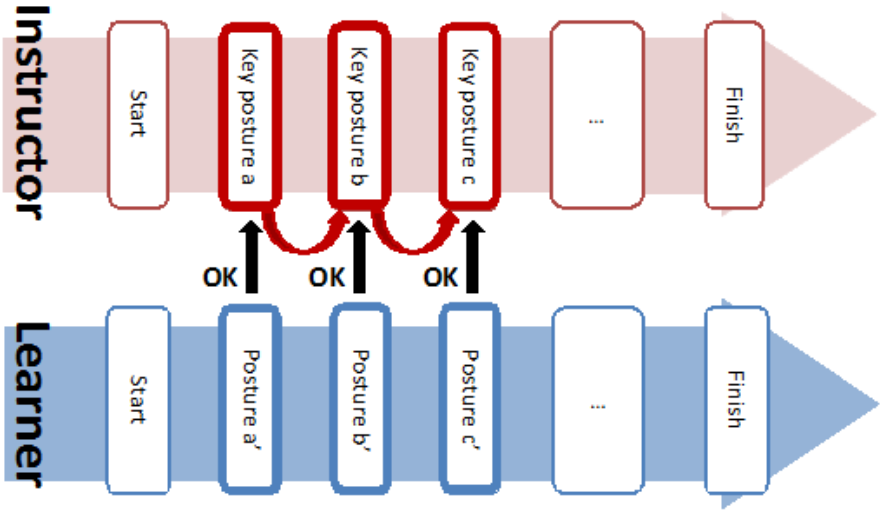

Fig. 2. Step by step learning model of instructor's motion. At first, key posture a of instructor is presented to learner. If learner can make almost the same posture as key posture a, key posture b is presented to learner for the next step.

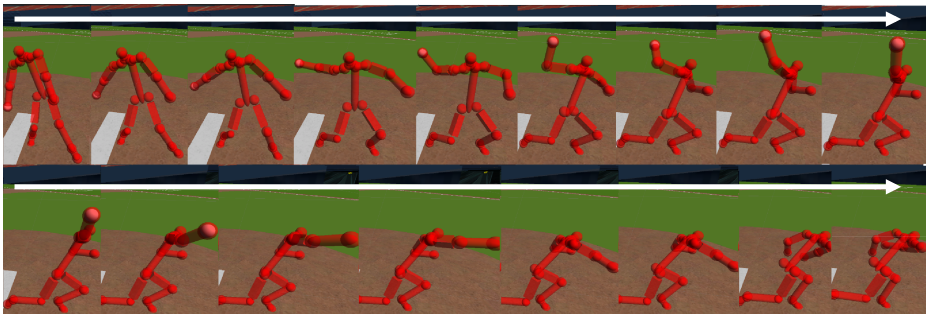

Fig. 3. Instructor's pitching motion captured by Microsoft Kinect. Instructor's pitching motion is divided into 17 steps.

4 Developed System

Fig. 5. illustrates the developed system configuration. Learner trains her/his pitching motion by observing the difference between herself/himself and instructor through head mounted display. Learner's viewpoint is fixed onto the head of learner's 3D model. Lerner's 3D model is captured by Microsoft Kinect in real time.

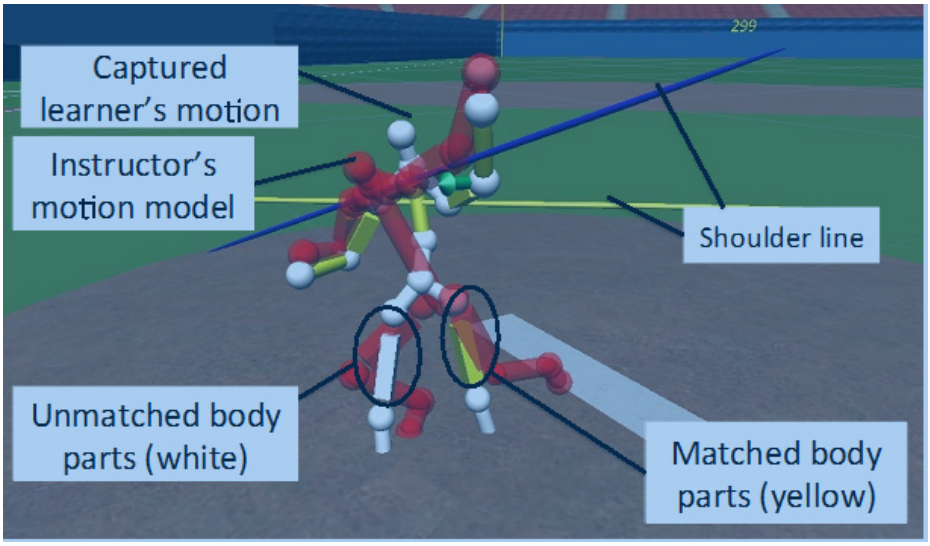

Fig. 4. Visualized difference of the posture of instructor and learner in virtual environment

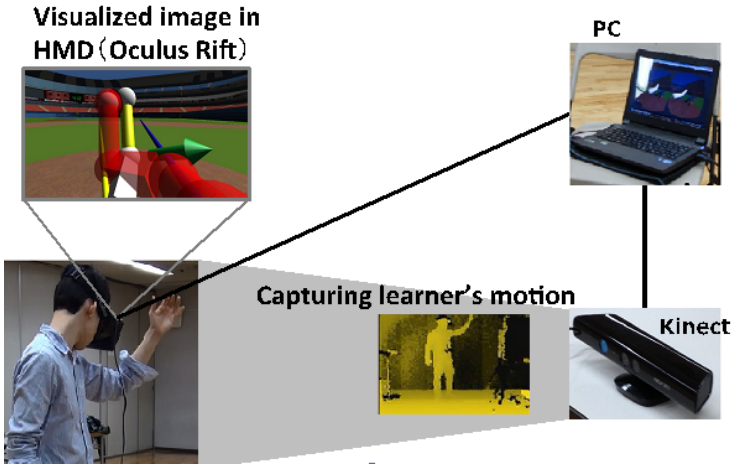

Fig. 5. System configuration

5 Experiment

We conducted an experiment in order to evaluate the efficiency of developed physical skill training system. For an evaluation we compared three different learning methods. As a conventional learning method we used video of instructor's pitching motion (video). As proposed methods we prepared two different parameters for evaluating the conformation of the posture of learner and instructor. First one compares all the

part of learner's body parts strictly with instructor's targeted posture (fullbody). Second one relatively put weight on shoulder line for matching the posture (part). Participants of the experiment are randomly chosen whichever method for training.

We had 17 participants, in the age of early 20s, for the experiment. Experiment procedure is as follows. Participants are asked to throw a ball with opposite arm of dominant arm.

Pitching ability is measured by average throwing distance calculated by throwing a ball 5 times before and after training with whichever training method for 7 minutes. 6 participants used fullbody condition, 5 participants for part condition, and 6 participants for video condition. Fig. 6. shows an image of an experiment.

Fig. 6. Experiment image of throwing a ball with opposite arm of dominant arm

6 Results

Fig. 7. shows the result of measured improvement of throwing distance of participants in each condition. Only participants used part condition for training made a significant improvement in throwing distance ($p<.05$).

From the result that participants used part condition for training made a significant improvement, effectiveness of proposed method for training physical skill in a sport activity has been proved. For the training of fullbody motion, it is more effective to let learners to pay attention to certain points of the body that whole body movement at the early stage of training.

We also made an interview after the experiment. Some participants used fullbody condition for training mentioned that if they had more time for training, they could improve the pitching ability. It requires a further experiment but if we conduct an experiment for a longer time period, effectiveness of fullbody condition may be shown in the result.

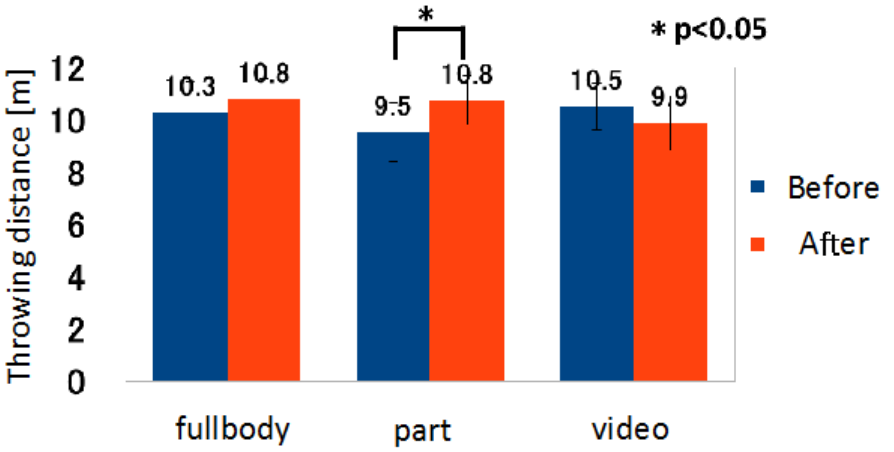

Fig. 7. Training effect results

7 Conclusion

In this research, we proposed a first person view physical skill training system in immersive virtual environment using head mounted display. As a training method for sport activity, we designed step by step learning model that allows learner to observe instructor's motion according to learner's training speed. We conducted an experiment of training pitching skill and compared proposed method and conventional video learning, and proved an effectiveness of proposed method.

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