AR based Skill Learning Support System with Velocity Adjustment of Virtual Instructor Movement

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Abstract: In this paper, we propose the skill learning support system to give learner the real time feedback information. In this system, to construct feedback, the virtual room based on recorded user's image is used. In virtual room, instructors bone model is displayed too. In learning process, learner imitates displayed bone model to get the knowledge about skill corresponding to instructor's movement. By displaying virtual instructor and learner's body in the virtual room, learner can see virtual instructor's movement and learner's posture. Additionally, virtual instructor's speed can be adjusted by learner's intention. To control virtual instructor's speed, learner's voice is used as input information. To get user's voice and record image, Microsoft Kinect sensor is used as a camera and a microphone in the developed prototype system. To evaluate this approach, the prototype system for learning skill of soft tennis (swing form) was developed. So, evaluations experiments were conducted by using the prototype system of soft tennis and effectiveness of adjustment of virtual instructor's speed in learning process was shown.

Keywords: Skill Learning, Augmented Reality, Velocity Adjustment, Soft Tennis

1. Introduction

Recently, in support of skill learning techniques, measurement devices have often been used to record learner movements. Many studies have developed supportive learnings to enhance the skill learning techniques. Gotoda conducted research on a training support method using measurement technologies (Gotoda, Matsuura, Nakagawa, Miyaji, 2013); this method provided the learners with a real-time system for learning the shot timing in tennis. The system predicted the trajectory of the ball by measuring the position of the ball from the moving image and by analysing the change in position of each frame. By using the system, a learner can easily learn appropriate shot-timing. However, motion capture in support of skill learning techniques remains very expensive. One example of a motion-capture device is the Microsoft Kinect sensor. Kinect can measure joints without markers, and therefore, Kinect is widely used to develop learning support system (Hamagami, Matsuura, Kanenishi, Gotoda, 2012; Tamura, Uehara, Maruyama, Shima, 2013; Chuang, Kuo, Lee, Tseng, Hsu, 2013) and rehabilitation system (Meng, Fallavollita, Blum, Eck, Sandor, Weidert, Waschke, Navab, 2013) and learning support system (Akawaza, Takei, Nakayama, Suzuki, 2013; Anlauff, Cooperstock, Fung, 2013; Iwane, 2012; Mitsuhara, 2012; Shih, Wu, Chen, 2013; Thakkar, Shah, Thakkar, Joshi, Mendjoge, 2012). In particular, Ochi et al. (2013) proposed the air squat training support system using the Kinect to measure user movements. By using the Kinect, the system obtains skeletal information from the side suitable for an air squat. The system can create feedback from the skeletal information for the learner. Yamaoka et al. (2012) proposed a system for the flying disc throw; the proposed system captures a learner's arm movements, checks their height, and displays feedback messages to adjust their actions.

On the other hand, in our research group, we proposed a skill learning support method, in which the learner imitates a display showing arm movements (Sumimoto et al., 2013). Our method presents the orbit of the bending and stretching motions of the arm to the learner. In this paper, through experimental results, we show our method for skill learning in slow motion. Thereby, we prove that the presentation velocity affects learning. Therefore, in this study, we propose a skill learning support method that considers velocity adjustments of the virtual instructor. By adjusting the velocity of the virtual instructor, our system teaches at a suitable rate based on the time of learning. While learning, a learner can adjust the virtual instructor's speed in order to successfully imitate the instructor's movements. As feedback, the virtual instructor is displayed using AR-technology (Augmented Reality-technology). In this paper, we describe the prototype learning support system for soft tennis, and detail our experiments using this prototype system.

2. The AR Based System for Skill Learning Support System

2.1 System Summary

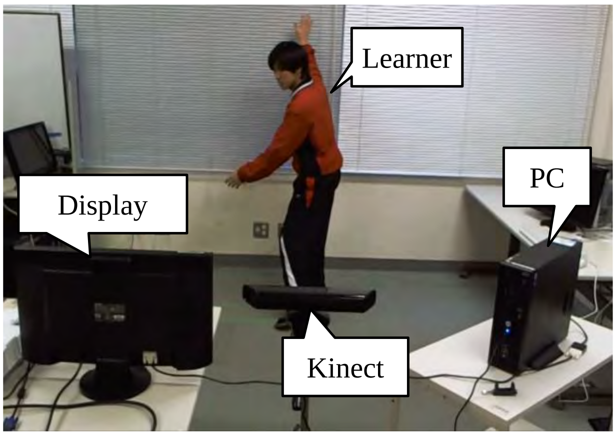


Figure 1. Overview of the Proposed System.

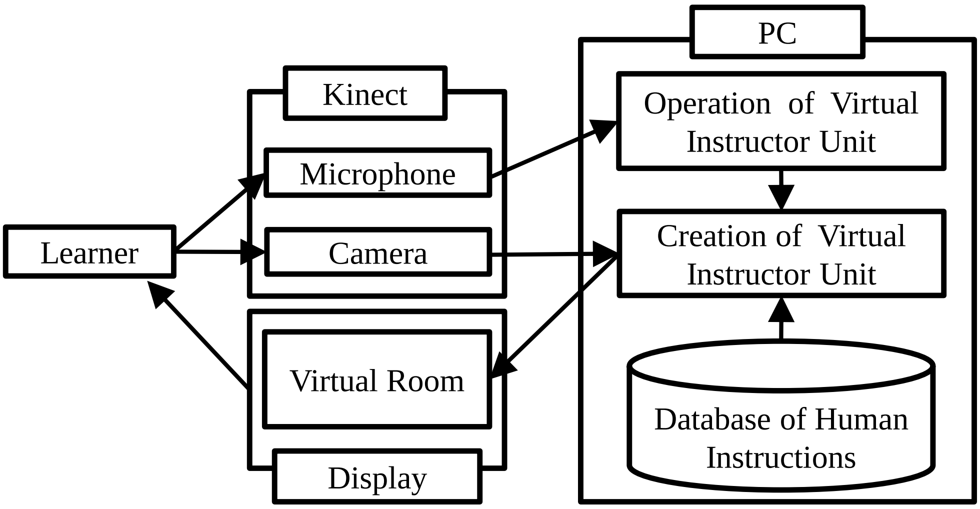


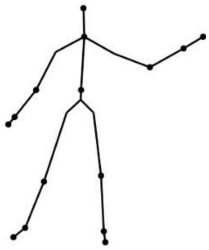
Figure 2. Framework of Proposed System.

Figure 1 shows the overview of the proposed system. The system consists of the display, Kinect and PC. Figure 2 shows the framework of the proposed system. The system has two units: the operation of virtual instructor unit and the creation of virtual instructor unit. The operation of virtual instructor unit adjusts the velocity of the virtual instructor via instructions from the microphone. Feedback is sent on the display. Figure 3 shows the feedback. The system develops the feedback by adding the virtual instructor to the image captured by the Kinect. The virtual instructor is displayed as a skeleton, and makes some soft tennis swing motions.

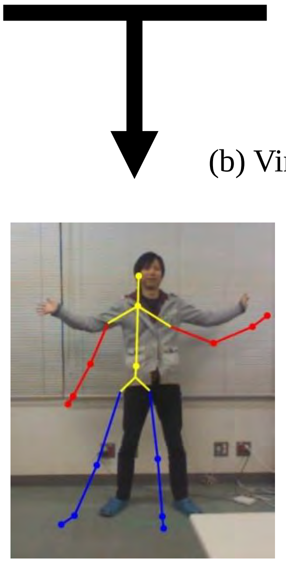
2.2 Virtual Room and Velocity Adjustment of Virtual Instructor

Figure 4 shows the virtual room presented on the display. Figure 4 (a) is the display of the virtual instructor in the virtual room. The virtual instructor presents the movement instructions. Figure 4 (b) is an example of the virtual room during learning. The learner learns soft tennis skills by imitating the movement of the virtual instructor. The virtual instructor's current speed is displayed in the left corner

(a) Image captured from camera

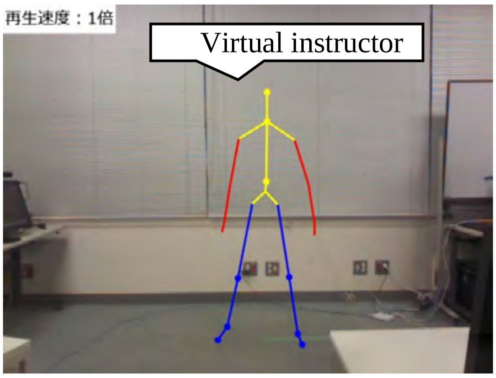


(b) Virtual Instructor（bone model）

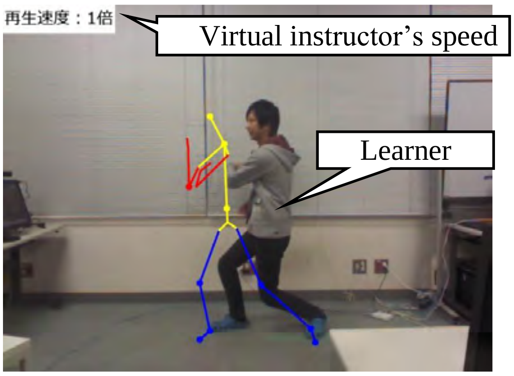


(c) Feedback

Figure 3. The Feedback Image for the Learner.



(a) Displaying Virtual Instructor
in Virtual Room



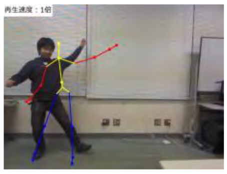
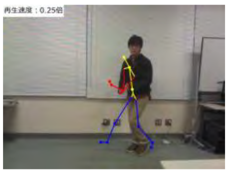
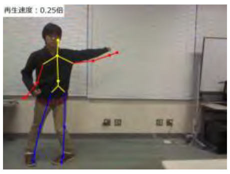
(b)Example of Virtual Room
in Learning Process

Figure 4. Virtual Room Produced by The System.

of the virtual room, as shown by Figure 4 (b). In the virtual room, adjusting the virtual instructor's speed changes the virtual instructor movement.

In this system, the learner can adjust the speed of the virtual instructor movement. The adjusted movement of the virtual instructor and its normal movement are shown in Table 1. From the images in Table 1, at first, the learner cannot obviously imitate the virtual instructor movement at normal speed. By adjusting the virtual instructor's speed, the learner is expected to imitate the movement. This adjustment is conducted by learner's verbal instructions. Therefore, the learner can adjust the velocity without using his or her hands.

Table 1. Differences of displayed time

time(sec)	adjusted movement(slow)	normal movement
1		
2		
4		
8		
12		
16		

3. Evaluation experiment

3.1 Purpose and Condition

We conducted an experimental evaluation of the system, wherein three types of virtual instructors were prepared (to teach back swing, fore swing and smash). The subjects were three college students (A, B and C) who were inexperienced at soft tennis. The velocity of the virtual instructor for subjects A and B was set at slow speed. The velocity of the virtual instructor for subject C was set at normal speed. The velocity of the slow subject was one-quarter of the normal speed. The subjects imitated the virtual instructor's movement 60 times for each form (total of 180 movements).

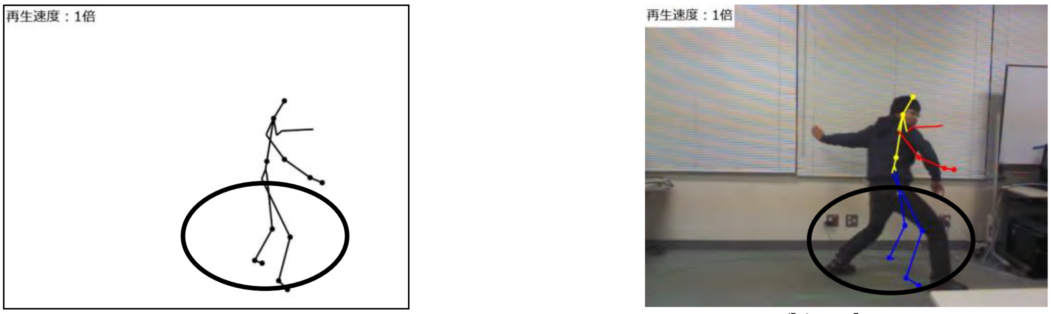
3.2 Result

As examples of results of experiment, virtual instructor and subjects' steps about back swing are shown in Figure 5. Red circle and blue circle corresponded to left foot and right foot respectively. Foot positions of subject A and B are similar to the virtual instructor. However foot position of subject C is reverse. By slowing the virtual instructor movement, it was found that the subject can imitate the movement more easily. In addition, examples of subject C are learning results of fore swing and smash are shown in Figure 6 and 7 respectively. In particular, the wrong movement of subject C shows in

(a) Virtual Instructor (b) Subject A

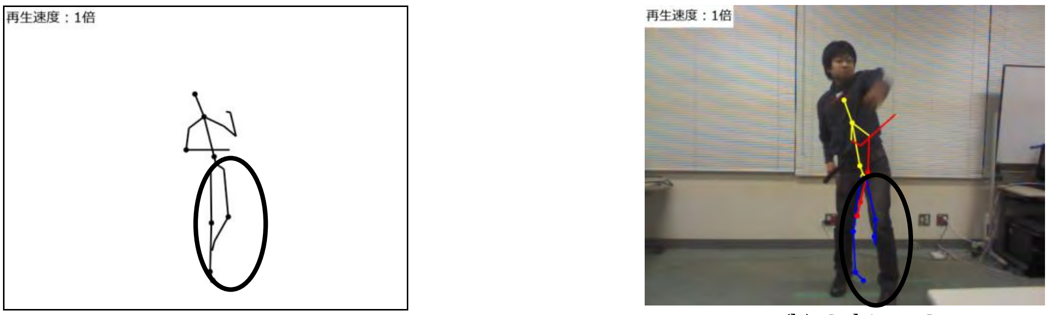
(c) Subject B (d) Subject C

Figure 5. Difference of Subjects' Step (form: back swing, time: 3sec).



(a) Virtual Instructor (b) Subject C

Figure 6. Wrong Step of Subject C (form: fore swing, time: 3sec).



(a) Virtual Instructor (b) Subject C

Figure 7. Wrong Step of Subject C (form: smash, time: 4sec).

circles in these figures. Although, subject C cannot imitate the virtual instructor movement, it is expected that other subjects can get knowledge of suitable movement from given the virtual instructor. Right movements (fore swing, back swing, smash) have 21 important points (such as positions of foots). By using developed system with slow speed virtual instructor, it is found that subject A can get all points knowledge. Subject B can get 16 knowledge (76%). On the other hand, subjects C can get only 10 knowledge (47%). From these results, it is expected we confirmed possibility that the learner can acquire the skill by imitation the virtual instructor at the slow velocity.

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4. Conclusion

This study proposed a skill-learning support method considering the velocity adjustment of the virtual instructor. We developed a system that presents the virtual instructor with velocity adjustment. From the results of the evaluation experiment, we confirmed the possibility that the learner can acquire skills by imitating the virtual instructor at the slow velocity.

In future works we will improve the system by adding other feedback methods (such as voice feedback). In addition, we will need to conduct a detailed evaluation experiment to verify what skills can be taught when a subject chooses to run the virtual instruction at full speed.

Acknowledgements

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