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A Movement Instruction System Using Virtual Environment

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Abstract - This paper proposes a movement instruction system using virtual environment. This system consists of a monitor, cameras, and a PC. A learner is coached by a virtual instructor that is displayed in virtual environment as 3 dimensional computer graphics on the monitor. Virtual instructor shows sample movement and suggests mistakes of learner's movement by recognizing movement of learner's movement from the picture that cameras capture. To improve the robust characteristic of information from cameras, the system enables to select optimum inputs from cameras based on learner's movement. It implemented by Fuzzy associative inference system. Fuzzy associative inference system is implemented by bi-directional associative memory and fuzzy rules. It is suitable to convert obscure information into clear. We implement and evaluate the movement instruction system.

I.INTRODUCTION

By the progress of computer networks, many movement learning system are proposed, developed, and utilized. It is required on many occasions such as physical education in the school and when people learn movement themselves. But, many of movement learning contents are text contents and can't suggest mistakes of learner's movement. So learner can't image correct movement and can't repeat to practice efficiently.

This paper proposes a movement instruction system using virtual environment. The system is consists of a monitor, cameras, and a PC. A learner is coached by a virtual instructor that is displayed in virtual environment as 3 dimensional computer graphics on the monitor. Virtual instructor shows sample movement and suggests mistakes of learner's movement by recognizing movement of learners from the picture that cameras capture. Consequently, learners can learn movement by themselves.

Cameras of the system capture learner's movement by using Intelligent-Space Software. Intelligent-Space Software can detect information of learner's movement from the picture that is captured by camera. Therefore, the system can capture learner's movement without special equipments such as optical sensor and magnetic sensor. To improve the robust characteristic of information from cameras, the system enables to select optimum inputs from cameras based on learner's movement. It implemented by Fuzzy associative inference system. Fuzzy associative inference system is implemented by bi-directional associative memory and fuzzy rules. It is suitable to convert obscure information into clear.

The movement of learner is displayed in virtual environment on the monitor. The system recognizes the movement of learner's arms and feet from the joint angles. The system evaluates the movement of learner by comparing learner and virtual instructor's movement. If the joint angles of learner are close to the joint angles of sample, the color of learner's body on the monitor changes to green. As the difference between sample and learner's joint angles widen, the color of learner's body on the monitor change to yellow, and red.

We implement a movement instruction system using virtual environment and evaluate the system by experiments. As a result, we confirm that learners can learn movement efficiently by themselves.

The procedure of learning movement in this system explained in section II. How to evaluate the movement of learner explained in section III. Capture system is explained in section IV. Section V describes experiments and the results. And section VI is the conclusions of this paper.

II.PROCEDURE OF LEARNING MOVEMENT

The scene of learning movement is illustrated in Figure 1. And the system overview is illustrated in Figure 2.

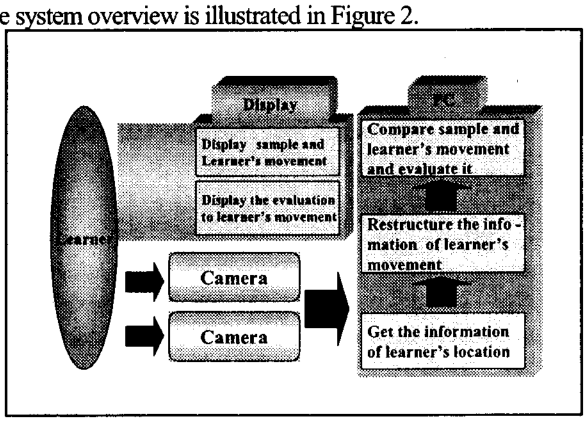

Figure 1 .The system overview

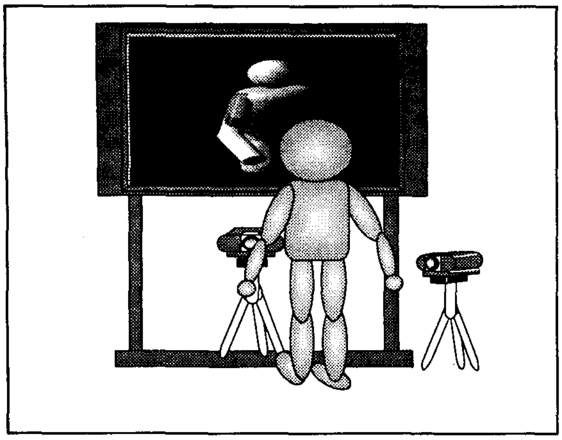

Figure 2. The scene of learning movement of the system

A. Procedure of learning movement

The procedure of learning movement on the system is as follows.

1) Learner looks sample movement that the virtual instructor shows on the monitor. Learner can look any viewpoint that learner want.
2) Learner imitates the sample movement.
3) The system captures the movement of learner and displays it as 3 dimensional computer graphics with virtual instructor's movement at the same time on the monitor.
4) Learner and virtual instructor's movement overlap each other and are transparent.
5) Learner's movement is evaluated and changed the color of body on the monitor into green, yellow, or red in accordance with level of difference between learner and virtual instructor's movement.
6) Learner recognizes the level of difference between learner and virtual instructor's movement sensuously and exactly.
7) Learner tries to improve the movement repeatedly.

The procedure of learning movement on the system satisfies the following conditions that are important at the time of learning movement.

a) Learner can obtain image of the movement for looking at the sample movement.
b) Learner can imitate, and can understand sensuously and exactly what you mistake in your movement.
c) Learner can repeat efficient practices in order to obtain skill.

B. Virtual instructor on the monitor

Figure 3 shows virtual instructor on the monitor. Learner can only learn about right arm movement in this system. Virtual instructor's arm is white, and learner's arm is red. Learner gets the image of movement from Virtual instructor's arm and recognizes mistakes from learner's arm. These arms are transparent because it is easy for learner to compare them.

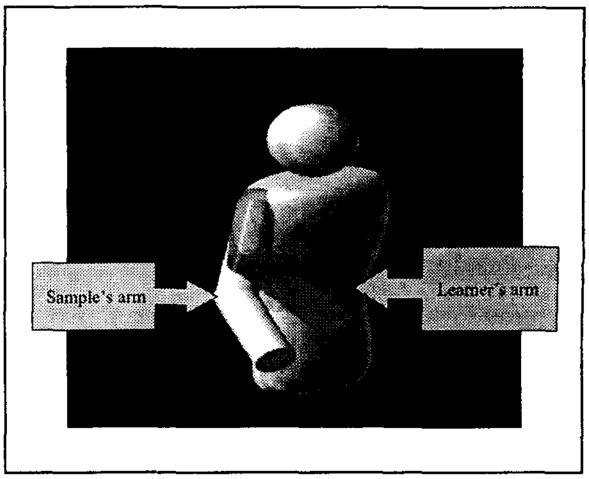

Figure 3. Virtual instructor on the monitor

III. EVALUATION FOR LEARNER'S MOVEMENT

The system evaluates the movement of learner by comparing learner and virtual instructor's movement. If the joint angles of learner are close to the joint angles of sample, the color of learner's body on the monitor changes to green. As the difference between sample and learner's joint angles widen, the color of learner's body on the monitor change to yellow. And difference between sample and learner's angles still wider, the color of learner's body changes to red. The system compares a shoulder and an elbow angles from the front and the right side. If learner's shoulder angle from the front is θ_1, the learner's shoulder angle from the right side is θ_2, sample's shoulder angle from the front is θ_1', and sample's shoulder angle from the right side is θ_2', evaluation algorism is likes Figure 5.

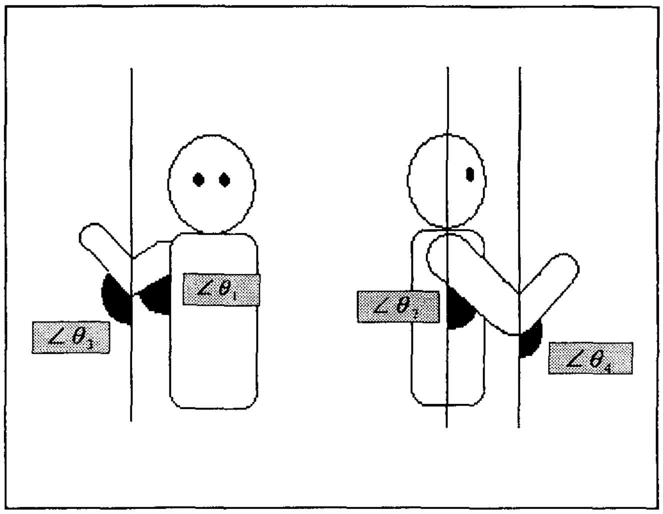

Figure 4. Location of detected angle

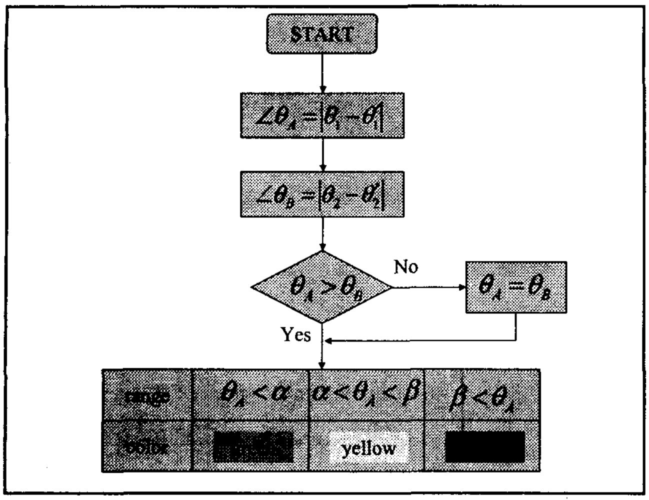

Figure 5. Evaluation algorism

By using one angle of θ_A and θ_B, evaluation algorism became simple. The color of part from shoulder to elbow is decided by the shoulder angle. The color of part from an elbow to wrist is also decided by the elbow angle. By evaluating each part separately, learner can know detailed evaluation. α and β is range angles. These angle are decided when we measure the sample movement. Experts in many kind of the sport have a regular width in their movement. So it is appropriate to change the color of learner's body on the monitor to green when the learner's movement is in this width. Therefore, if α defines as half of sample movement width, when $\theta_A < \alpha$, the color of learner's body on the monitor changes to green. And if β defines as 2α, when $\alpha < \theta_A < \beta$, the color of learner's body on the monitor changes to yellow. In the same way, when $\beta < \theta_A$, the color of learner's body on the monitor changes to red.

IV. CAPUTURE SYSTEM

Cameras of the system capture learner's movement by using Image processing software (we call the software A-space. A-Space can detect location of specific point, which we specify, from the picture that is captured by camera. The detecting points are shoulder, elbow, and wrist. $\theta_1, \theta_2, \theta_3$, and θ_4 are calculated by the location of these three points. Therefore, the system can capture learner's movement without special equipments such as optical sensor and magnetic sensor.

To improve the robust characteristic of information from cameras, the system enables to select optimum inputs from cameras based on learner's movement. When cameras capture the learner's movement, the shoulder, elbow, and wrist often enter the camera's blind spot. The system equips two cameras for each location from difference angle and selects optimum inputs from cameras based on learner's movement. It implemented by Fuzzy associative inference system. Fuzzy associative inference system is implemented by bi-directional associative memory and fuzzy rules. It is suitable to convert obscure information into clear. So it is utilized to judge the optimum inputs from obscure information of learner's movement.

Figure 6 shows architecture of fuzzy associative inference system in this system. It has three layers, if layer, rule layer, and then layer. Three layers construct fuzzy rule. Between these layers are composed of bi-directional associative memory. Location of learner's shoulder, elbow, and wrist are inputted to if layer. And information which camera is optimum is outputted by fuzzy rule that is incorporated in fuzzy associative inference memory. And location from camera that is selected, are reconstructed and evaluate.

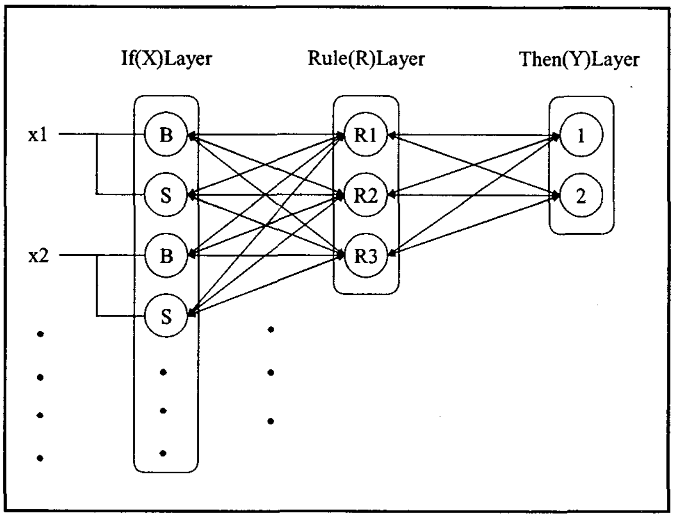

Figure 6. Expression of Fuzzy rule with associative memory

V. EXPERIMENTS AND RESULTS

A. Experiments

A scene of experiment is shown in Figure 7. A sport that learner learn is table tennis. We measured movement of expert 20 times. And range angle α and β was calculated at 0.2[rad] and 0.4[rad]. In this experiment, learner learns about movement of smash. The questionnaire is carried out, because the impression of learners is very important factor for this system. The questionnaire has three questions. 1) Can you understand sample and own movement sensuously? 2) Can you understand sample and own movement precisely? 3) Can you repeat to practice efficiently? Learner answers the questions by number 1to 5 (5: Excellent, 4:

Good, 3: Fair, 2: Bad, 1: Very bad).

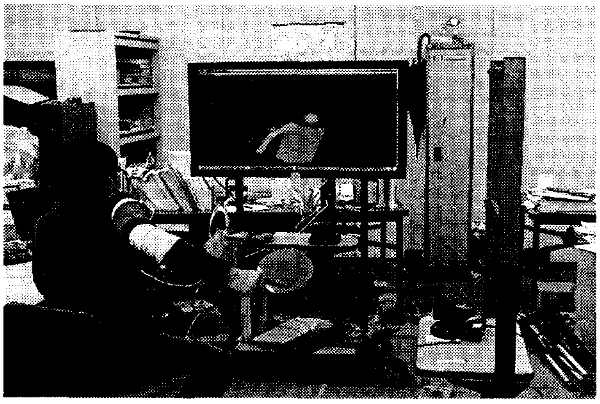

Figure 7. A scene of experiment

B. Experimental results

The experimental results for this system is shown in Figure 8. As the result of impression , the rate that learners answered "Excellent", and "Good" is 100% of the question 1), and 85% for the question 2), and 100% for the question 3). It shows that the movement instruction system using virtual environment is effective for learning movement.

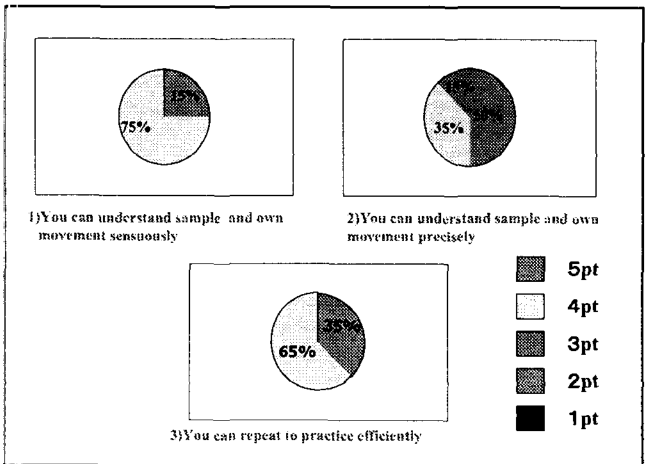

Figure 8. Result of the question

VI. CONCLUSION

In this paper, we proposed the movement instruction system using virtual environment. We implement the system and evaluated by experiments. As a result, we confirmed that learner could learn movement sensuously and precisely, and could repeat to practice efficiently.

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