A Study of Educational System for Learning Body Movements by Distance Learning - Application to Introductory Swimming Education -

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Abstract

This study aims at constructing a distance learning system for learning body movements. We took "body movements of swimming" as an example. Two methods were developed for displaying body movements: a method of displaying to a learner mainly characters and motion pictures and a method of reproducing movements in 3D computer graphics (3DCG). To verify the effectiveness of these two methods, we conducted a questionnaire survey and an actual application experiment, and further investigated a proper procedure in the teaching material by the image for learning body movements and psychological effects on the learners. These investigations clarified that, when learning body actions, 3DCG forms were more suitable than increasing in presentation screens of information on teaching materials and increasing in the volume of information presented at a time. The experiment also clarified that we were able to expect an increase in a learner's willingness for learning by using this system. Moreover, a certain academic level can be expected to be kept regardless of the education level of teachers. In conclusion, this system can be said to be effective for "education of human-body movements." We also described briefly a system proposed to compare human-body movements with those of the model in a simple way using a web camera.

1. Introduction

Swimming is popular among many people [1], because it is an exercise of whole body movement and the load to the body is light. Since swimming is a sport in water and it is necessary to synchronize the movement of each part of the body, it is effective to receive instructions directly from a teacher to learn this movement.

There is, however, a problem of limitations of time and a place in receiving instructions from the teacher directly. We therefore place a focus on "distance leaning" that has been developed in a variety of educational sites in recent years. We are aiming at the construction of such a distance-leaning system that presents time-and-place-constraint-free swimming education.

As similar research that the movements of swimming are displayed by animations, Noji *et. al.* developed swimming animations using underwater imaging [2]. The focus of this research was not placed on educational support, but on extracting 3DCG body-action data from video images.

Moreover, a system that can observe the animation of the Olympics player's swimming from 26 directions is open to the public on the web site named Swimming.jp [3]. Even though this is an effective system for experts, it is not necessarily suitable for a beginner to study swimming. In this research, an effective swimming-education-support system is made for beginners of swimming.

2. Learning Method of Swimming

When one wishes to study swimming, he or she usually goes to a classroom in a swimming school and receives instruction directly from the teacher. Exercises such as "leg movements," "arm movements," "breath," etc. are practiced inside as well as outside the pool. As learning methods of swimming at home, on the other hand, there are "learning by imagination of body movements," "learning using textbooks [4] and videos, " etc.

In actual educational sites, there is a problem that information on movements in water is not enough given because it is obstructed by water. Therefore, the learner should supplement information on the teacher's movement in water for him/herself. And a difference in the experience of the learners directly leads to a difference in understanding. Moreover, it is difficult to understand the synchronization of each part of bodies such as "arm movement" and "leg movement" when the learner learns them at a place where there is no buoyancy.

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A method of solving these problems may be to arrange the number of people of the learners and teachers, and to educate in detail in water. However, this method is difficult to achieve due to the limitations of the number of teachers, a place, costs, etc. Therefore, a study of swimming styles by imagination is also necessary for the learner in the pool as well as at home.

As for learning of swimming at home, there is a "learning method by the imagination of body movement" and a "learning method using textbooks, videos, etc." Major information in textbooks does not include movements. Moreover, it is difficult to understand the body action because there is no flow like dynamic scenes. Dynamic scenes are effective compared with assistance and the supplementation with imagination.

Next, we will describe a dynamic scene study. Observation of the dynamic scene by supplementation with imagination is very effective. However, only the same recorded dynamic scene is repeated. In addition, the camera angle of this dynamic scene is fixed. Such a study tends to become passive and it is difficult to imagine swimming styles correctly.

In this study, we develop a new swimming-education-support system that can assist learners to imagine swimming styles or can supplement the imagination, by which movements can be displayed by dynamic scenes, not from the specified camera angle, but from various angles.

3. Outline of the System

This section describes the outline of the system. We first demonstrate an example of the education in which movements of the free style are instructed in an actual "educational scene." The free style is instructed in the order of "movement of the legs," "posture," "movement of the arms", and "breath."

Next, in a study using this system, the instructions are presented in the similar order. It is necessary, however, to enable the learner to access to an arbitrary guidance program according to his/her proficiency. Therefore, the education program was arranged in the tree structure, which enabled the learner to study efficiently by watching the scenes only for a short time. Figure 1 shows the flow chart of this system.

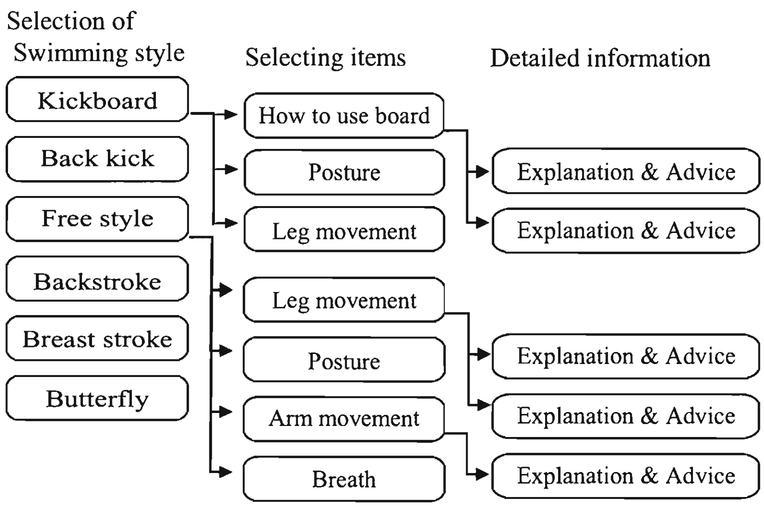

Figure 1: Flow chart of the system.

We simplified the contents of the system and the interface so that a beginner could easily operate the system. The system explains the contents using dynamic scenes and sentences based on the contents of guidance in actual educational sites [5] [6].

3.1. Display of Movements by Trihedral Figures

A system that displayed movements by trihedral figures had been made for trial purposes before making "a system for the display of human movements by 3DCG." The operation procedures here are explained as follows.

1. On the selection screen of swimming style, the learner selects a swimming style and its learning item that he/she wants to study from the list shown in Table 1.

2. A synchronized animation is presented from the three directions (the front, the side, and the lower side) on the screen respectively, and the item-selection screen of the selected swimming style is displayed on the explanation screen located on the lower-left of the whole screen.

3. The learner selects a part of the movement from the list displayed on the left of the explanation screen.

4. "Explanation of the movement" corresponding to the selected items and "Notes etc." are presented by "animations" and "sentences. "

Table 1: Swimming styles and learning items.

Selection of swimming style	Selecting items	Selection of swimming style	Selecting items
Kickboard	How to use board	Backstroke	Leg movement
	Posture		Posture
	Leg movement		Arm movement
Back kick	Back bobber	Breast stroke	Leg movement
	Leg movement		Posture
	Posture		Arm movement
	Position of hands		Position of hands
Free style	Leg movement	Butterfly	Leg movement
	Posture		Posture
	Arm movement		Arm movement
	Breath		Position of hands

3.2. Questionnaire Survey of the Trihedral-Figure-Based System

A questionnaire survey of this system was conducted for 44 university students and 10 teachers of swimming. The questionnaire consisted of 6 questions that asked the effectiveness of the swimming education using "a system for the movement display by the trihedral figure." The questions were answered by selecting either of "yes, " "no, " or "others. " Besides the questions, spaces were prepared to fill in "good point," "problem," and "impression" of this system. The questions are as follows.

1. Do you want to use this system?

2. Does your skill progress by using this system?

3. Is the education by "the system for the human-body movement display by the trihedral figure " appropriate?

4. Do you feel odd in the human-body movement of animation?

5. Can you imagine a human-body movement easily by using this system?

6. Does learning at home become possible by using this system?

3.3. Results and Discussions

Figure 2 shows the results of the questionnaire. More than 90% of the subjects answered "yes" to the question No.5 asking "Can you imagine a human-body movement easily by using this system?" There is a problem, on the other hand, that it was difficult to watch "synchronizing animations" displayed on many screens and "character information" simultaneously.

However, some experts who were able to imagine "animations between separate screens" also had the opinion that "it became easy to imagine movements." As a result, the enhancement of learners' willingness for learning can be expected by displaying swimming style by animations.

The majority of the teachers of swimming and the experienced people answered "no" or "others" to the question No.1. Many of their answers were that they did not need the system because they could swim. Many opinions, however, were

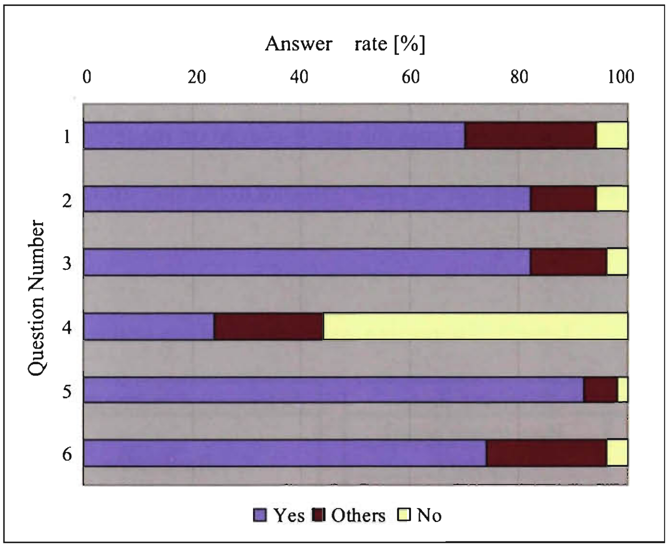

Figure 2: Results of the questionnaire.

also observed that they thought that the system was effective if a beginner used it. These results are desirable because the purpose of this research is the construction of a system intended for beginners.

In question No.4, about a quarter of the subjects answered that they felt odd in the animations of the human-body movements. Among them, many subjects answered that they felt odd especially in the animations of the bottom view of the trihedral figures (Fig.3). The reason for this may be that the perspective is elusive because this system uses plural number of two-dimensional animations and it is difficult to image actual movements intuitively from the animations of the bottom view.

4. Display of Human Movement by 3DCG

To overcome the disadvantage of the system mentioned in the previous section, we next developed another system that used 3DCG human-body model, aiming at reducing odd impressions of animations and increasing in the freedom of observation.

4.1. Measurement Method [7] [8]

A present motion capture device needs many measurement devices, and it is not easy to construct an environment similar to this [9]. We therefore aimed at taking "body movements" for our system as accurate as possible by a simple method.

The setting of 30 frame/sec and 640 × 480 pixels was used, and two digital video cameras (Hereafter, called "DVC") were arranged at the front and the side. The marker tapes were put on the target, and the location information was acquired

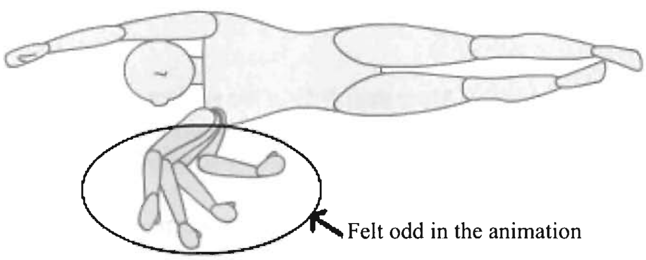

Figure 3: Animation of the bottom view of a trihedral figure.

from each camera. Furthermore, this location information was fed to the model of 3DCG, and the 3DCG animations in this paper were made by using the technique of " the forward kinematics, " by which we calculated the position from the starting position, each length, and the angle of each joint.

"Movements of the target" were taken ten times for the reason that the number of DVC was few and that the frame rate was low. Then, the average tracks of each part were measured from this information.

4.2. Interface of Human Movement Display by 3DCG

The interface in "display of movements by 3DCG" also displayed "Point of movement" and "Method of Practice," etc. by itemizing the elements of the tree structure as in the case of "Movement display of trihedral figures." The movements were displayed by selecting the item in the animation of 3DCG model, and the system explained "movements to be studied" using simple figures and sentences on the explanation screen located at the lower part of the screen.

Moreover, this system newly added "float" that had risen to the result of the questionnaire for the beginners of swimming described in Subsection 3.1. Figure 4 shows the operating procedure.

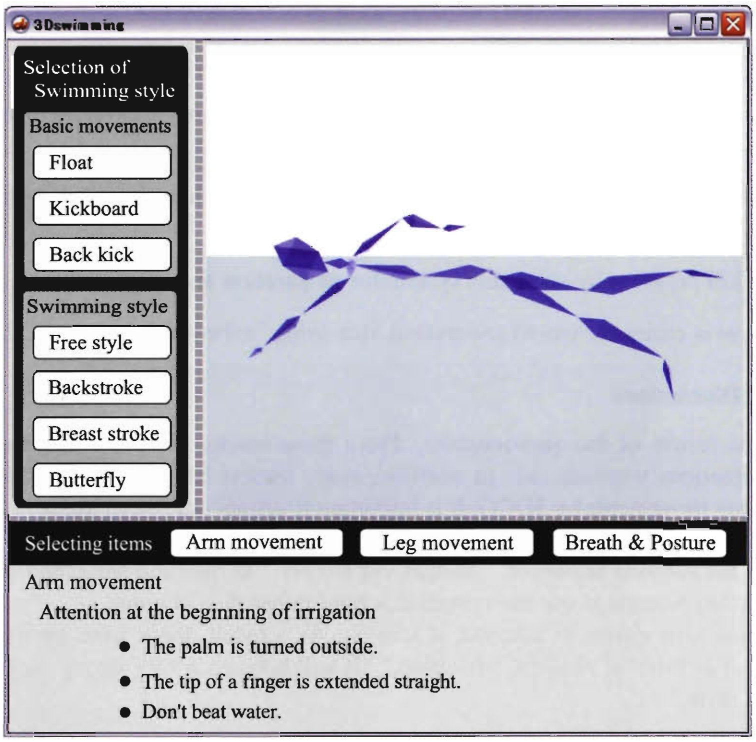

Figure 4: Operating procedure.

1. First, the learner selects a swimming style that he/she wants to study from the seven swimming styles, as the procedure in " the movement display by the trihedral figure."

2. A 3DCG animation of the operation of the selected swimming style is displayed on the screen, and the explanation screen is displayed at the lower part.

3. The learner can adjust a camera angle by dragging the left button of the mouse in the display screen of the 3DCG model, and dragging the right button yields a "zoom-in" and a "zoom-out."

4. On the explanation screen, important points of movements and how to practice are displayed by items, and animations and simple figures of the movements are further displayed by selecting one. Moreover, the model's movements can be observed by a mouse operation from an arbitrary angle.

4.3. Questionnaire Survey of the 3DCG-Based System

This subsection describes the questionnaire survey conducted to confirm the effectiveness of "the system for the movement display by 3DCG."

Forty-four subjects (21 experts and 23 beginners) from their 10's to 50's joined this questionnaire survey. They evaluated both systems for the movement display by 3DCG system as well as by the trihedral figure. The subjects were different from those who had answered the questions listed in Section 3. The expert subjects were asked to answer the questions assuming that "beginners used it."

Questions consisted of eight items that compared between "the system for the movement display by the trihedral figure" and "the system for the movement display by 3DCG" in addition to the questions listed in Section 3.

Besides the questions, spaces were prepared to fill in "good point," "problem," and "impression" of this system.

The questions are as follows.

1. Do you think that this system can attract interest in your learning of swimming?
2. Do you feel odd in the human-body movements of animations by the trihedral figures?
3. Do you feel odd in the human-body movements of 3DCG animations?
4. Can you imagine a human-body movement easily by using this system?
5. Do you think that you understand swimming skills better by using this system than by using a conventional teaching material such as a textbook?
6. Do you want to use this system instead of a conventional teaching material such as a textbook when you learn at home?
7. Does your skill progress by using this system for preparation and a review?
8. Which system is easier for you to understand, that using "trihedral figures" or "3DCG"?

4.4. Results and Discussions

Figure 5 shows the results of the questionnaire. From these results, we knew that the odd feeling of the human-body movements of animations was reduced. In addition, many leaders had the opinion that their interest in swimming was roused by displaying movements by 3DCG. It is important to attract interest of learners in learning swimming, which was a favorable result when considering the advantage of using this system.

About 40% of the subjects answered " neither yes nor no " to question No.7, and some subjects were of the opinion, as the reason, that they wanted to use the system at school rather than at home.

This system was also shown to teachers at school. As a result, there were answers such as "I want to use it as a teaching material at lectures of physical education," "It will become a very strong support for a teacher who is not good at swimming education," etc.

5. Confirmation of Introduction Effect

5.1. Method

Two groups actually used both systems: "movement display by the trihedral figures" and "movement display by 3DCG." The two groups consisted of ten children from 4 to 8 years old, and they were divided into groups A and B. The difference in the progress level was compared between the two groups.

The children in Group A actually used the system for about five minutes before the beginning of the class, and afterwards, they took a conventional program. The children in Group B took only a conventional program. They used the system for a month (once a week × 4). Figure 6 shows the process of this confirmation experiment.

5.2. Results

The Group A children who used the system came to be more aware of their own swimming than the Group B children. As a result, there were also children who had made progress in their form remarkably. Moreover, other children also seemed to be interested in the system and gathered when the Group A children were using this system.

However, although children at the age of 4-5 years old showed an interest in the system, it seemed to be difficult for them to apply the swimming of 3DCG model to their own swimming.

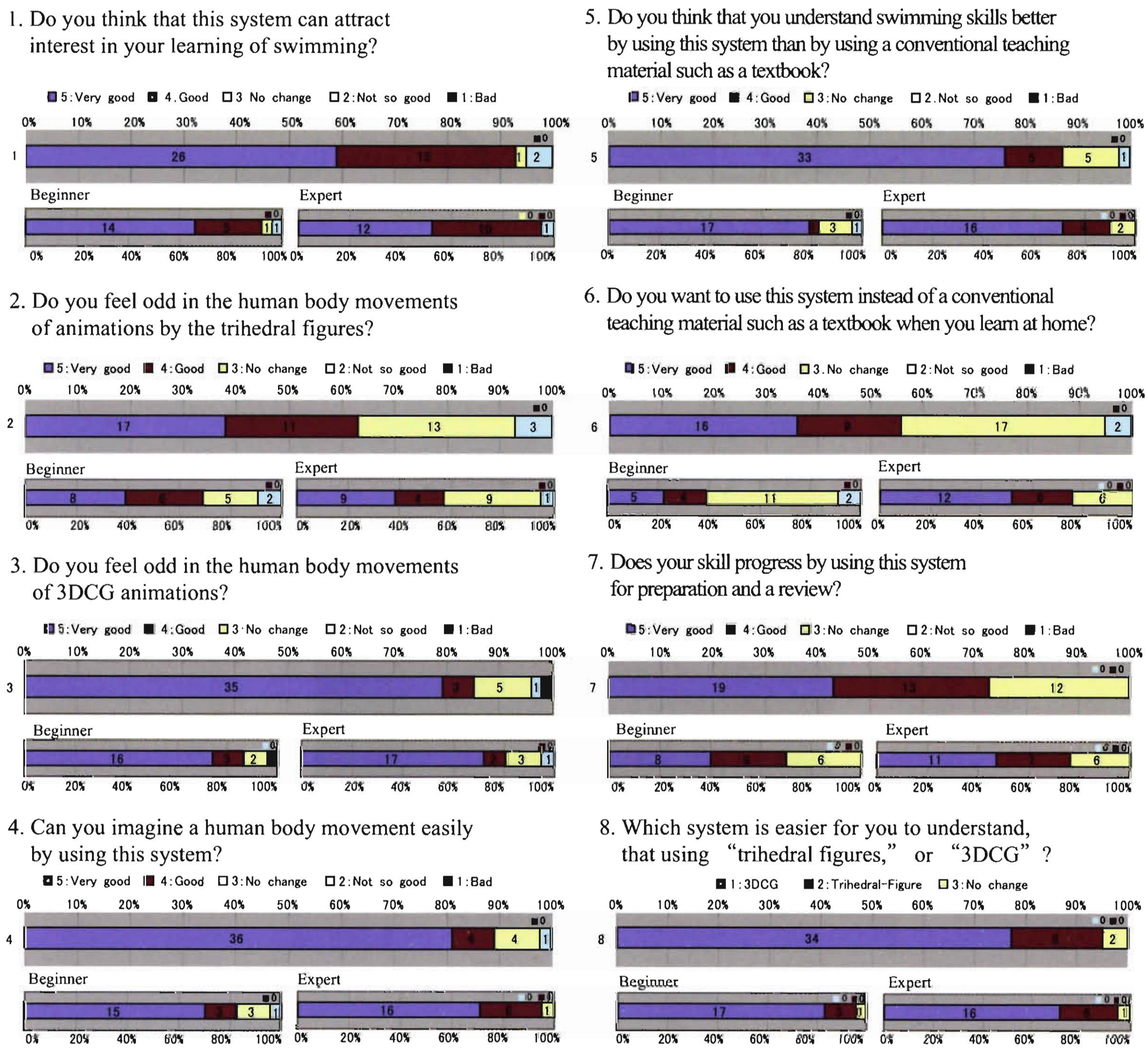

Figure 5: Results of the questionnaire.

6. Simple Comparison of the Human Body Movements

As a result of the introduction experiments, we knew that it was difficult for beginners to apply the movements of 3DCG to their own movement. We therefore proposed a system that conducted a simple comparison of human-body movements with those of the model using a web camera. We here describe the system developed for trial purposes briefly.

In places other than a swimming pool, movements of the lower half of the body cannot be practiced because there is no buoyancy. We therefore placed a focus on the practice of movements of the upper-body when using this system.

First of all, the learner connects the web camera with the personal computer. This capture image is displayed in the background of the learning system. At this time, 3DCG model is displayed by translucent. The learner's existence region is extracted by the background subtraction. And, the existence region of 3DCG model is compared with the range with which it overlaps.

The 3DCG model changes the surface color when the learner's movement exceeds the allowance of the error margin, and warns (Fig.7). As a result, the difference between the learner's operation and the model operation can be visually recognized directly. Figures 8 and 9 show the case of misjudgment and success, respectively.

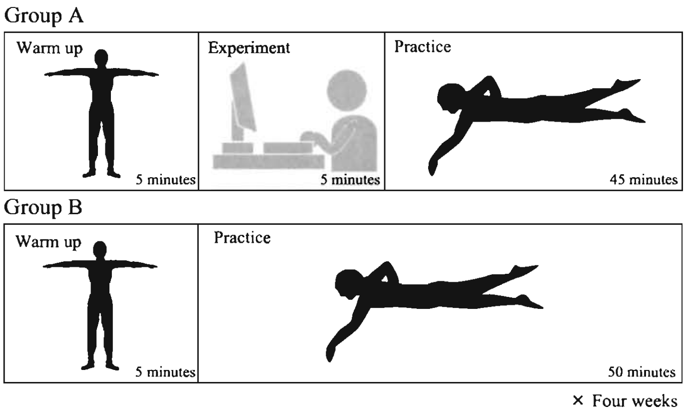

Figure 6: Process of Confirmation Experiment.

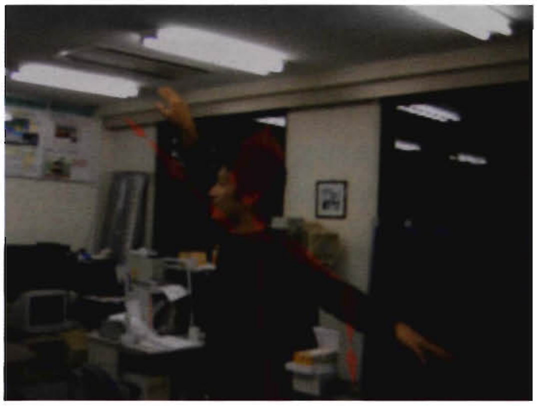

Figure 7: Case of the learner's movement exceeding the allowance of the error margin.

7. Conclusions

This paper has clarified that, when learning body actions, 3DCG forms on which the learner arbitrarily obtained information are more suitable than increasing in presentation screens of information on teaching materials and increasing in the volume of information presented at a time.

The experiment described in Section 4 has clarified that we are able to expect an increase in a learner's willingness for learning by using this system. Moreover, a certain academic level can be expected to be kept regardless of the education level of teachers. In conclusion, this system can be said to be effective for "education of human-body movements."

We have also described briefly a system proposed to compare human-body movements with those of the model in a simple way using a web camera. By using this system, a future work will be to develop an automatic evaluation system of a learner's movement.

8. Acknowledgments

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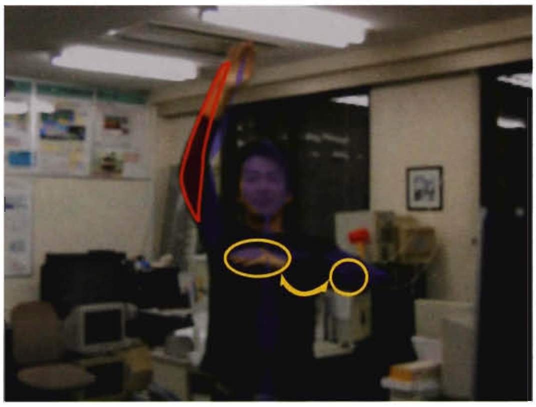

Figure 8: Case of misjudgment.

Figure 9: Case of success.

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和文抄録

遠隔学習による動作学習教育システムに関する研究
ー水泳導入教育への応用ー

高内　一平[1]，山本　奈緒[1]，飯田　尚紀[2]，武田　昌一[3]

身体動作を学習するための遠隔教育システムの構築を目標として，身体動作の閲覧には，文字・動画像を中心とした手法と，動きそのものを3Dコンピュータグラフィックス(3DCG)のキャラクタで再現する手法を水泳を例題として開発した．そして，この2つの手法の有効性の検証のために，アンケート調査と，導入実験を実施し、学習者に与える心理的効果と，身体動作学習のための映像教材に適切な手法の調査を行った．実験の結果，身体動作の学習において，その教材自身に「情報の提示画面」を増やし，一度に提示する情報量を増やすことより，学習者が任意に情報を得られる3DCG形式の方が適していることが分かった．更に，本システムを使用することで学習意欲の増加などが期待できることが分かった．また，教師の教育レベルに関わらず，ある一定の教育水準を保つことが期待出来ると考える．以上より，本システムは身体動作教育に対して有効であると考えられる．更に，容易に実行可能なwebカメラを使用したモデルと人体動作を比較するシステムの提案についても触れた．

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