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Extraction Method of Characteristics of Important Body Shapes and Their Training Order for Motor Skill Acquisition

Jinya SUMIZAKI [a] & Tomoko KOJIRI [b]
[a] *Graduate School of Science and Engineering, Kansai University, Japan*
[b] *Faculty of Engineering Science Kansai University, Japan*
[a]k436997@kansai-u.ac.jp

Abstract: For acquiring motor skills, players are often taught body shapes of the specific timing in the movement Such body shapes are not defined for all movement, even though the specific timing is known. Such important body shapes (IBS) are the characteristics of the body shapes that can be seen from successful players and that are not seen from unsuccessful players. This research proposes the extraction method of IBS of the specific timing from the body shapes of successful/unsuccessful players. On the other hand, players sometimes set easier sub-goals before training the target motor skill. The IBS extracted by the sub-goals may be easier to acquire than those extracted by the target movement. This research also determines the training order of IBS by the difficulties of sub-goals/target movement from which they are acquired.

Keywords: Motor skill, discriminant analysis, training order

1. Introduction

Motor skill is a skill of using the body to accomplish a specific movement (task). Such motor skill is implicit so that it is difficult to acquire it. One of the ways of acquiring it is to given advices by other players or coaches. However, other players or coaches do not always exist. Therefore, it is preferred to give training method of the motor skill even there is no other players or coaches.

Several studies introduced motion capture devices to get the body movement data of players for the purpose of analyzing them or comparing them with the data of others (Linden, Schoonderwaldt, Bird & Johnson, 2011). By these systems, players were able to understand the characteristics of their body shapes during the movements. However, they were not able to understand which timing in movement are inappropriate and which characteristics the ideal body shape should has. Some systems indicated the differences of the body shapes of the player from that of the experts (Ghazali, Shahar, Rahmad, Sufri, As'ari & Latif, 2018). However, they indicated only the differences in the movement so that players need to discriminate important differences by themselves. Such judgement is difficult for the novice players.

Kohda developed training support system for the feint motion in one-on-one scenes of a team sport, basketball (Kohda, Matsuura, Tanioka, Karungaru, Wada & Gotoda, 2018). The system has the swinging speed of the legs at a particular timing as correct movement and checks it with player's movement. In this system, the correct movements are defined manually by authors. Therefore, there might be some other movements or characteristics of the body shapes that may be important but are not recognized. In addition, the characteristics of important body shapes are not defined for all movement even specific timing is known.

The objective of this research is to propose the extraction method of the characteristics of the body shapes of the specific timing automatically. This research calls such characteristics as important body shapes (*IBS*). The IBSs are the characteristics of the body parts that can be seen from players who are able to move the body and that are not seen from players who cannot move the body to accomplish the movement. This research grasps body shape data of the players by the motion capture device and determines IBSs by their co-relations based on the success of the movement.

Players usually set easier sub-goals in training the target movement and IBSs can be acquired by the sub-goals as well. IBSs acquired from the easier sub-goals may be easier to get than those

acquired from the different ones. Therefore, this research also determines the training order of IBS by the difficulties of sub-goals/target movement from which they are acquired.

2. Method for Extracting IBSs

IBSs are characteristics of the body parts that are seen in the body shapes of the successful players and are not seen by the unsuccessful players. In order to extract such IBSs, this research:

1. introduces motion capture devices, such as Kinect, to acquire the body shape data, and
2. executes discriminant analysis to determine the degree of co-relations of body shape data of each body parts with the success of the movement.

Discriminant analysis is a method for predicting which group an unclassified sample belongs to by analyzing the relationship between the characteristics of the data and the classified groups. It is used when there is a linear co-relation between the groups and the features related to the discrimination of the groups. Its objective is to find a_1 to a_n of the discriminant equation expressed as follows.

$$Y = a_1x_1 + a_2x_2 + \cdots + a_nx_n + a_0$$

Values of Y represents the groups. In this research, the positive values are defined as failure and the negative as success. x_1 to x_n represent the features of each body shape data. a_1 to a_n are the weights of x_1 to x_n used to divide the data into groups, and a_0 is a constant term. a_1 to a_n represent the contribution of x_1 to x_n in determining the value of the group, which reflects to the co-relation of x_1 to x_n with success.

The IBS of each body part that has the highest co-relation with the success usually one. The body shapes similar to IBS are expected to have the higher co-relation. Thus, body shapes whose co-relation with the success is higher than criteria are extracted as IBS. Then, IBS is represented as the range of minimum value and maximum value of x_i. Let's assume that Figure 1 shows the angles of the right arm and their co-relation with success. In this example, the ranges that exceed the criteria is 40 to 80. Therefore, the IBS is determined as (40, 80).

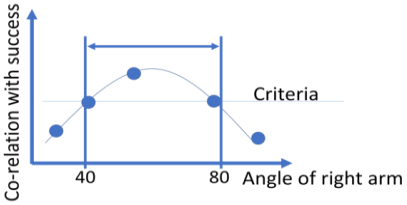

Figure 1. Example of Body Shape Data of Angle of Right Arm.

3. Method for Determining Training Order of IBSs

In order to train the specific movement, we often set sub-goals. For example, let's assume the movement of throwing the ball with 150km/h to the catcher's mitt. Its sub-goal probably is to throw the ball with 140km/h. The IBSs extracted from the sub-goal may be easier to get than those from target movement. However, IBSs that are acquired only by the sub-goals and are not by the target movement are not important for the target movement.

According to these assumptions, this research determines the training order of IBSs by the following policy:

1. IBSs of sub-goals are trained in prior to those of target movement.
2. Within the same sub-goals or target movement, IBSs who have the larger co-relation are trained in prior to the others.
3. If there are the same IBSs that are acquired from the different tasks, it should be trained only once and the latter one is eliminated.
4. If there are IBSs whose body parts are the same but their shapes are different and if the latter one includes the former one, the body shape of the former one is changed to the latter one's and the latter one is eliminated.

Let's assume that angles of joint points are detected as IBS as shown in Figure 2. The numbers in the circles indicate the order of the co-relation with the success: 1 means that the IBS has the strongest

co-relation with the success. Firstly, these IBSs are ordered from the sub-goal ones to the target movement ones along with the strength of the co-relation.

Left elbow: 30-80 -> Right wrist: 120-130 -> Left elbow: 30-60 ->Right wrist: 120-140 -> Left knee: 90-120

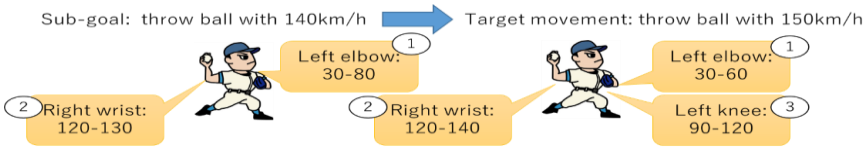

Figure 2. Example of detected IBSs.

Since angle of the left elbow of the sub-goal is broader than that of the target movement, "left elbow: 30-80" should be trained first and then "left elbow: 30-60" needs to be tried later. On the other hand, "right wrist: 120-130" should not be necessary because "right wrist: 120-140" is enough for attaining the target movement. Therefore, "right wrist: 120-140" is trained in substitute of "right wrist: 120-130" of the sub-goal. As a result, following training order is determined.

Left elbow: 30-80 -> Right wrist: 120-140 -> Left elbow: 30-60 -> Left knee: 90-120

4. Trial Use

We have applied proposed method to determine the IBSs for the target movement "throw a ball to the target position," which has two sub-goals. The body shape data were angles of joints that were calculated by the positions of 20 joints acquired by Kinect. 20 body shape data were acquired for each body parts for every sub-goal/target movement from 16 players. As a result of applying our method, following IBSs and its training order are determined.

Neck: 50-70 -> Left elbow: 60-80 -> Left hip: 100-120

We have asked five experienced baseball players about the acquired IBSs. More than four answered that left elbow and left hip were necessary. As for the neck, three answered unnecessary. Instead, they answered that the eye direction was necessary. The angle of the neck effects on the eye direction, so that we considered that the neck was also appropriate.

5. Conclusion

In order to support for training the target movement, this research proposed a method for extracting important body shapes of the specific timing of the movement from players' trials. In addition, it introduced the method for determining the training order of the extracted body shapes based on the difficulties of tasks from which they were acquired. The proposed methods were applied to derive the training order of body shapes for the target movement "throw the ball the target position." However, currently, we have not evaluated the IBSs and their training order acquired by the method. We need to evaluate the validity of the result and show the effectiveness of the proposed method.

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