# Support on Repeating Skill Development - Modulating from monitored data to a target

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**Abstract:** This study develops a methodology to support repeating action as motor-skill development of human beings. Repetitive motion, which is the center of our interest, is a series of the same motion at a trial time. Therefore, a waveform of monitored data can imply the characteristics of the body motion. Comparison of such a waveform with others can help learners understand the difference of the motion between them. However, it is difficult to identify and compare the different amplitude and frequency of waveform by way of the display reviewing at the same time without any modifications. Hence, this study aims at proposing adjustment method of the different waveform in different trials.

**Keywords:** motor skill, motion capture system, learning skill, real-time supporting

## Introduction

Learning is not only regarded as intellectual activity but something on physical change and potential change to be improved. Therefore, academic approaches on learning physical skill are carried out in various fields such as sports and cooking with different ways. For example, “The Cambridge handbook of expertise and expert performance” [1], “Skill acquisition in sport: research, theory, and practice” [2] and “Expert performance in sports: advances in research on sport expertise” [3] are relevant articles on this study. Researchers in learning science or developers of educational systems rarely tackle to this domain because their main concerning is in intellectual activities so far. By the way, what difference can be seen in between from methodological viewpoint? This is our original inquiry since 2007 [4]. What we have in mind are published in several articles that deal with some specific skills; i.e. running skill [5].

This study supports people who tend to acquire motor-skills of the repetitive motion. In respect to detecting skills of repetitive motion, it is carried out by whether heart rate is stable or not, time/distance increasing, keeping form of whole body or parts-body and so forth. As a performance estimation, it can be monitored in such ways that heart rate expresses periodic beats per minutes, time/distance expresses hour, minutes, and seconds/kilometers and meters, action form expresses three-dimensional coordinate and so on. These performance data can be treated as the numerical values in this way.

From research perspectives, we will discuss a supporting scenario with three kinds of skill process. The internal process of the physical motion as skill-developing cycles includes target selection, cognition, action selection, action and memory. The superficial

process of the physical motion as skill consists of stroke that trial, input performance and review. Therefore, technical base as these processes consists of a stroke that includes monitor function, data storage, detect/identify, modeling, strategy and feedback, is done to support acquiring skills.

## 1. Target Learners of the Study

The target skill type of this study takes comparative long term at a trial. For example, running, swimming and jumping rope has the series of the same action during the performance. In other words, repetitive motion is the continuous motion that repeats the same behavior in a certain rhythm due to the physical and environmental conditions. Therefore, a waveform of monitored data can imply the characteristics of body motion. However, to keep the same action is difficult for novice people because of the changing condition of the body, mind and the environment through the performance. We call body and mind change during the trial "internal condition" whereas the environmental change is called "external condition".

It is necessary with this study to focus concrete learners as research targets because the analysis and the supporting methodology might be different between a novice and an expert even if the similar data is detected. It depends on the intention, ability, flexibility and scalability of a skill performance. We discussed target learners in a hierarchy that includes beginner, intermediate and advanced (See Figure 1). We sometimes call them in another words like "novice" "average" and "expert". With a traditional approach, we should define the different method for skill development to each of the level respectively shown in Figure1. We assume in this study that the target person belongs to beginner who intends to be up to the next level of intermediate. What we thought the beginner is that they do not acquire and perform the stable form during a trial.

Based on our assumption, the beginners have to strengthen the fundamental motion ability whereas experts can apply it along with the internal or external condition change. In other words, experts can perform various applied motion caused by adaptation abilities.

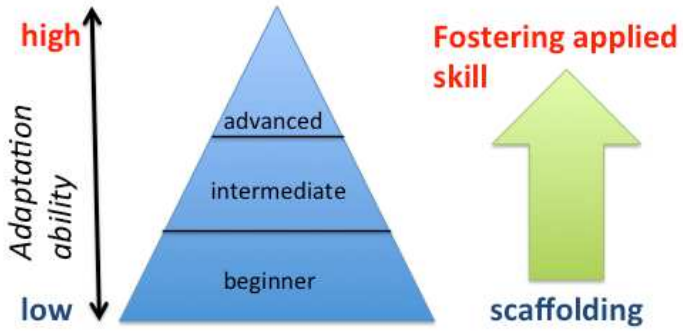


**Figure 1 Layer of skill learner**

## 2. Skill Development Process

### *2.1 Human Process*

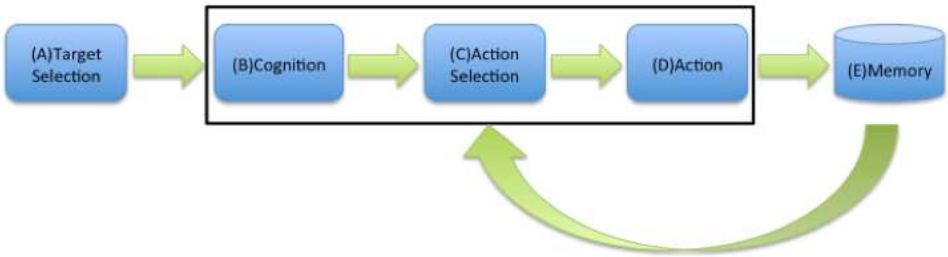


**Figure 2 An internal model of the learning process**

Figure2 represents an internal model of the human process in acquiring skills. We have discussed and modified from several original works on motor-skill development such as [7]. We assume that human-side process consists of five main parts as follows; (A) Target Selection, (B) Cognition, (C) Action Selection, (D) Action and (E) Memory.

The first process makes target selection in action. Target selection is a process that makes a target which skill is acquired or where skill level raise. In addition, target selection is performed through a number of times. Therefore, target selection tends to include in the next stroke of cognition.

Cognition process includes two strokes that perception and recognition. Perception is a stroke that sensory organs feel the stimulation from outside, whereas recognition is a stroke that the feeling stimulation in perception is determined or interpreted. After recognition, action selection is carried out.

Action selection is a stroke whether to select own action based on the information obtained by cognition process. After action selection, the person really starts motion. Action is a stroke that the learner acts what is selected by action selection.

Memory is to record the process and result of a performance at the process end. The process makes one cycle. Therefore, the cycle includes cognition, action selection, action and memory, and these loops. The memorizing result has also whether it succeeded or not. A loop of the second and subsequent times optimizes at the next loop by using a memory stored in the past. Repeating this loop leads to the acquisition of better performance. Therefore, this thing encourages the improvement of a skill.

As an example, jumping rope, that is one of the repetitive motion, is applied to this process. Target selection makes an intention to perform at next time whether the number of times to fly rope or time to fly the rope or an event of jumping rope. Cognition perceives in turning the rope by the sensory organs of eyes and hands that recognize the rope coming to the feet. If the learner catches up coming to the rope underfoot, he/she selects the action whether height and timing to fly the rope or turning fast and turning slow to tune speed of the rope he/she acts. Therefore, a learner memorizes the result of a trial in jumping rope. The resulting memory is used at next cognition, action selection and action to acquire the better result than that of previous cycle of flying rope.

### *2.2 Action Planning*

Figure3 represents an action plan at a trial. The process consists of three main parts as follows; (A) Trial, (B) Input Performance and (C) Review. At first, the process starts with a simple trial. The trial is a stroke that excises and gets the performance. After a trial, a learner inputs the information to a system that is obtained through the trial. However, the value of the performance differs depending on device and target skills. After inputting the performance, a review is carried out by the skill learner. The review process is necessary to check oneself from the objective viewpoint. Then, after reviewing, a stroke returns to trial. This stroke repeats to the status of development of the skill. If s/he unfortunately

fails, one can stop the cycle with satisfaction or negative mind in turn. This model has been associated with an internal model of the process described above. Trial is associated with a stroke of recognition, action selection, action and memory. Input performance is associated with a stroke of memory. Review is associated with a stroke of action selection, action and memory.

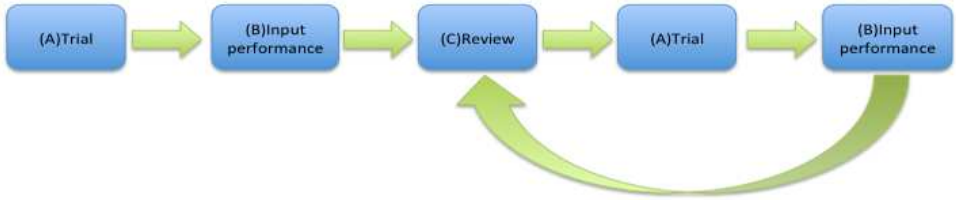


**Figure 3 Action plan in the skill learning**

*2.3 Technical Support*

With regard to the action plan in the former section, this section describes the design for the concrete system from the technical viewpoint.

(A) Action Monitoring

The monitoring device on the physical motion can be proposed in various ways such as sensors, camera and so on. Sensor data can be obtained with various physical quantities that are easy to be recorded. A camera data can be obtained with visual information. The target motion of the study intends repetitive motion. The monitored data from repetitive motion generates a waveform that represents the characteristics of the body. Therefore, this study uses motion capture system as monitoring device that is easily monitors the body motion with three-dimensional data [6]. The data from a motion capture system can be regarded as a waveform of the series of numerical values when motions of objects change, and the data can be obtained as three-dimensional images.

(B) Memory/Record

This study obtains numerical value of three-dimensional coordinate of time series by using motion capture system. The number of body parts to be monitored is fifteen points in total that are the head, neck, left shoulder, right shoulder, left elbow, right elbow, left hand, right hand, west, left knee, right knee, left heel, right heel, left toe, right toe.

(C) Interpretation

Data acquired in memory/record is used to make a graph whose vertical axis is three-dimensional coordinate of each body parts and the horizontal axis is time.

(D) Detection

The gap of acquired waveform becomes larger if two or more sample differs in height or other physical properties. Therefore, the gap-data should be filled to compare easily with the comparison target.

(E) Strategy

Target selection needs a strategy. Therefore, this study deals with the target form. As we considered that the target learner of this study is a beginner or a novice, it is necessary to learn the basic form for such a person. However, if this study targets intermediate and advanced who have already acquired the form of their own, we should consider whether it is necessary to present the target that matches a person rather than fixed targets. Learners recognize the difference between their own form and the model form. Then, one selects action to modify the form and he/she actually

acts. The learner memorizes the result more or less after the trial. S/he continues to learn more due to the result.

## 3. Skill Comparison

### *3.1 Requirement*

In this study, the system and its users can compare the monitored data with a visualized interface to compare skills at a time [6]. A visualized image in comparison is indeed important because it reveals the difference with well-coordinated deformation. However, it is difficult to compare the motion of other people in a same learning community with unprocessed data because the height, weight and other physical condition of a human is not the same between different persons. As a result, there is difference of height and operation speed between the stored data. Therefore, we should fill the gaps of the wave to a certain level in order to be compared appropriately in such conditions. The methods we have developed is (1) fitting the amplitude of the wave of the form in order to make up the height difference and (2) matching the frequency of the wave of the form in order to adjust the operation speed at a stroke.

### *3.2 How to adjust*

The motion data is based on the movement of markers on the body. However, the data obtained by motion capture system are discrete values. We thought the trajectory is not able to be seen as the continuous movement if one wants to slow down the playback speed. Hence, as a way to associate the different waveforms properly, if one wants to slow down the playback speed of the data, the system increases the number of data relating to a cycle by complementary of data. In doing so, we thought the operation of the smoother model can be presented by the learner.

On contrary, if one wants to make the playback speed at higher ratio, the system decreases the required number of appropriate data. In order to do so, to be the same the number of the own data and the other data according to a cycle, a continuous operation is seen without changing the playback speed.

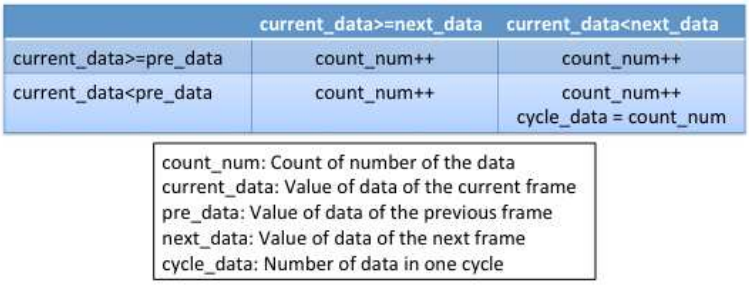


**Figure 4 Method of data count**

At next, comparison of the number of own one period and the number of others' one period is performed. In this case, if the number of own data is more than the number of others data, the number of other data is increased based on completion of data. In addition, if the number of own data is less than the number of others' data, the number of other data is decreased by thin out of data. Completion of the data takes place by generating an intermediate value between a point and a point. Thin out of the data is done by skipping the data if necessary. By repeating these operations, the system synchronizes them.

Concrete synchronized flow is to measure the number in one cycle from the y-coordinate of a data of the same marker ID from each of two pieces of data. This measured cycle is the next local minimum value from one local minimum value. Figure 4 represents counting data of one cycle. *Count_num* in the figure means counting the number of the data. The initial value of *count_num* becomes 1. *Cycle_data* is the number of the data in one cycle. *Current value* compares with previous value, and when *current value* is not less than previous value, *count_num* increments. When the *current value* is smaller than previous value and the *next value* is bigger than current value, *count_num* increments and *cycle_data* is the value of *count_num*. *count_num* is the initial value.

| learner_data>model_data | learner_data<model_data |
|---|---|
| Making point in model_data | Thin out point in model_data |

learner_data: number of the learner's data in a cycle
model_data: number of the model's data in a cycle

**Figure 5 Data Processing**

The way to synchronize is to change the distance the markers timing without changing the slope of the data by others from the ratio of the distance between each of the two markers. At first, each distance between markers of each of own data and others' data is calculated. For example, the distance of the head and neck is calculated in this way.

$$d = \sqrt{(head.x - neck.x)^2 + (head.y - neck.y)^2 + (head.z - neck.z)^2}$$

(d: distance, head.x: x coordinate of head, head.y: y coordinate of head, head.z: z coordinate of head, neck.x: x coordinate of neck, neck.y: y coordinate of neck, neck.z: z coordinate of neck)

This calculation uses the distance of 14 lines between the markers of 15 points (See Figure 6). The ratio of the distance between a learner's own and others' at the same marker ID is calculated. The position of markers can be change based on the ratio of them. As the right toe is a starting point of the marker, the point of the right toe adjacent to the right heel moves in the display by multiplying the ratio to the distance not to change the slope. The point is moved in parallel to the original slope as well. Match physique is performed these operation that would be repeated.

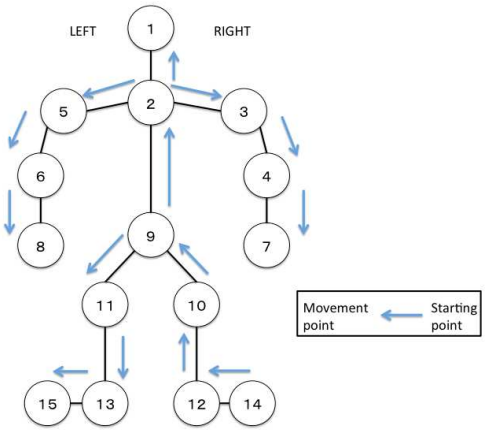


**Figure 6 Markers and their IDs**

## 4. Development

*4.1 System Configuration*

This system acquires location number of each part of the body in wearing a marker. The system is used at this time that is made by OptiTrack cooperation. We use OptiTrack FLEX:V100R2 as a camera device. This gray-scale imaging apparatus is possible to capture at 100 frames per second, which can be captured the agile behavior. This study, an environmental condition is indoor that gets less sunlight in the flat space of the size of 4㎡. We set up 6 poles and a camera stand. 10 cameras are set up at the poles and the camera stand. At this time, the cameras set up the position that the shooting range of the camera is as it captures the moving range when a learner acts in the center of this room.

*4.2 Snaphsot as an User Interface*

We describe the user interface here. The number of body parts obtaining the location information of the learner are 15 points where head, neck, both shoulders, both elbows, both hands, waist, both knees, both heels and both toes. Mounting position of the marker is the body parts needed to analyze the goal of form. With the motion capture system, it is necessary that the labeling body parts, which represents a marker. However, by creating a rigid body with a marker, the system has to know which maker ID indicates the place of a body. Therefore, head, both hands and waist in that the shape almost does not change in action so that they can be treated as a rigid body. A user wears three markers of plastic at each hand likewise s/he wears a cap with three markers. A learner also wears four markers around waist. At the points other than the head, both hands and the waist is performed labeling using this system.

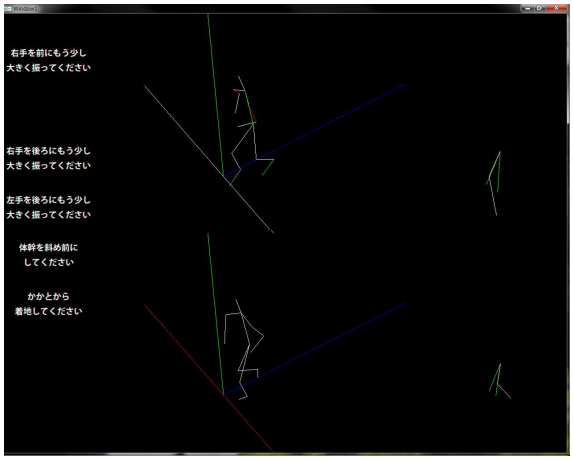


**Figure 7 A snapshot of the user interface**

This system arranged in descending order by using value of y coordinate from the retrieved data. The top five of them are upper side on neck, both shoulders and both elbows. Two small values of x coordinate are right shoulder and right elbow, in that the smaller value of y coordinate is right elbow. The larger value of y coordinate is right shoulder. Conversely, two large values of x coordinate are left shoulder and left elbow, in that the smaller value of y coordinate is left elbow. The larger value of y coordinate is left shoulder. The remaining marker is neck. At next, the bottom six of the first sorted in descending order are the lower body on both toe, both heel, both knee. Then three small values of x coordinate are right side and three large values of x coordinate are left side. Of the three, the largest value of y coordinate is the knee. In addition, the system labels the toe is how value of the z coordinate is larger in two smaller values of y coordinates and the heel is how value of the z coordinate is smaller in two smaller values of y coordinates.

This study provides feedback that uses a video in a large display during skill learning. Figure 7 is the snapshot of the display. Left side of the screen displays the advise of corrections by the system text. Center of the screen at the top displays a video animation of the trial motion of a learner. Center of the screen at the bottom displays a video animation of the motion of the referential model for this learner. Right of the screen displays a magnified part of the arm.

## 5. Summary and Future Works

In this paper, we proposed an environment that a learner can improve her/his form in repetitive motion by oneself in a community. We integrated a motion capture system to monitor a physical movement from three-dimensional perspectives. This study regards that the system presents the model form as the target form. The system supported to display the animation movie of the model and the learner' trial. We especially proposed a method that fills gaps between several actions. This study used motion capture system to obtain three-dimensional coordinate and frame, and obtained the form wave as skill. The learner improved to compare the animation movie of the model, which adjusted height and the speed of the motion to the learner's data, and the learner's trial.

This study supported for beginner in asynchronous. It is necessary to learn the base of the form for beginner. Therefore, the system presented a model of the same fixed to all. Future works is that a system supports for intermediate and advanced that has form of himself. If a system supports intermediate and advanced, we consider it is useful to provide a form of fitting himself more than a form of the emphasis base. Therefore, we develop a system that provides to find the form data of fitting a person.

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