Automatic Synthesizing System of Choreography for Supporting Contemporary Dance Creation

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Abstract

The purpose of this study is to support the creation of contemporary dance choreography using 3D motion data acquired by motion capture. In this study, we have developed “Body-part Motion Synthesis System” (BMSS) that allows users to create short choreographies by synthesizing body-part motions and to simulate them in 3D animation. Users can use the composed sequences as references for dance creation, learning, and training. Since the application runs on tablets, users can use it freely anywhere when they are creating dance choreographies.

This system automatically provides various short choreographies. First, users select a base motion and body-part categories. Then the system automatically selects and synthesizes body-part motions to the base motion. We randomly determined the synthesis timings of the selected motions. This feature allows countless variations of choreographies to be generated each time.

We propose a method that automatically synthesizes a sequence of motions by connecting choreographies based on the distance between starting/ending poses of motions, which would make it easier to consider the connectivity of choreographies. Based on this idea, a few choreographic motions that contain a pose that resembles to the starting/ending poses of the choreographic motions entered by user are connected.

We experimentally evaluated the effectiveness of BMSS 4.1 with 15 students who are studying dance choreography at two universities in Japan and USA. From the results of the experiment, we confirmed the effectiveness of this method for supporting dance creation.

1. Introduction

The purpose of this study is to support the creation of dance choreography using 3D motion data acquired by motion capture. We have been developing interactive simulation systems for dance using dance-motion archives. Automatic composition for ballet [1], contemporary dance [2], and hip-hop dance [3] using the motion clips of the whole body have already been developed in our project [4].

We developed Body-part Motion Synthesis System (BMSS) that allows users to create short choreographies by synthesizing body-part motions and to simulate them in 3D animation [5]. Since creating complex choreographies is very time-consuming, the BMSS version 3.0 supports the automatic synthesis of body-part motions to reduce the time needed to create them [6]. We experimentally verified its usability for choreographic education with contemporary dance majors [7]. In BMSS version 4.0, we improved it to interactively connect the short choreographic motions and play them as sequences. We probed its usability for choreographic creation by four professional choreographers [8]. This paper describes the latest version of BMSS with automatic generation of phrases and its evaluation.

There are some related works on computational dance study. Some research used dance notation and developed software applications [9, 10]. With this software, users can simulate already captured or precisely described dance animation. However, it is difficult to use these applications to compose original dances. A dance simulation system using 3D motion data with handwritten sketch inputs was developed [11]. However, it is also difficult to compose creative and effective choreographies using this system because the number of dance motions is limited. Our proposed software allows users to create an unlimited number of different varieties of dance movements.

Some studies have been made on synthesizing motions automatically using motion data. For motion combinations, one study automatically connected the basic motions of Japanese Noh and previewed them in 3DCG animation [12]. Other study focused on the synthesis of novel motion sequences from a database of motion capture examples using a statistical model [13]. Other study addressed motion synthesis using music, such as synthesizing dance motions based on emotions and the contents of a piece of music [14]. These studies generated natural motions by connecting or synthesizing multiple motions automatically based on rules. However, we support creation that targets contemporary dance without style or traditional manner restrictions. Rather than natural motions, our proposed system generates unexpected motions that are helpful for dances and choreographers.

2. BMSS

Figure 1 shows the Graphical User Interface (GUI) of BMSS version 4.1. This system automatically provides various short choreographic motions called Unit. First, users select a base motion and body-part categories. Then the system automatically selects and synthesizes body-part motions to the base motion. The system randomly determined the synthesis timings of the selected motions. This feature allows

countless variations of Units to be generated each time. The generated Units can be displayed as animation using 3DCG characters. Users can control the camera view or the playback speed of the animation. Favorite Units can be saved, composed, and played as Sequences of dance on timelines. A smooth transition to/from the synthesized motion, with the base motion's corresponding body-part, is achieved at the start and end timings of the synthesis to display them naturally.

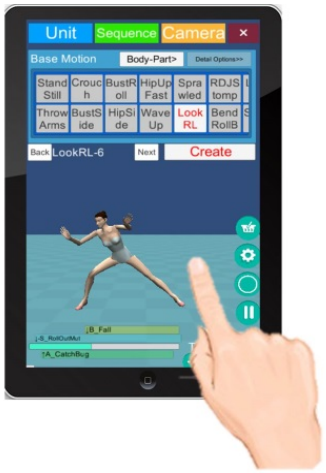

Figure 1. GUI of BMSS 4.1.

In order to consider the connectivity of Units, we suggest the automatic generation of Phrases, which are automatically generated combinations of some Units. User can create a Sequence by selecting some of the saved Units or the generated Phrases. Figure 2 shows examples of Unit, Phrase, and Sequence.

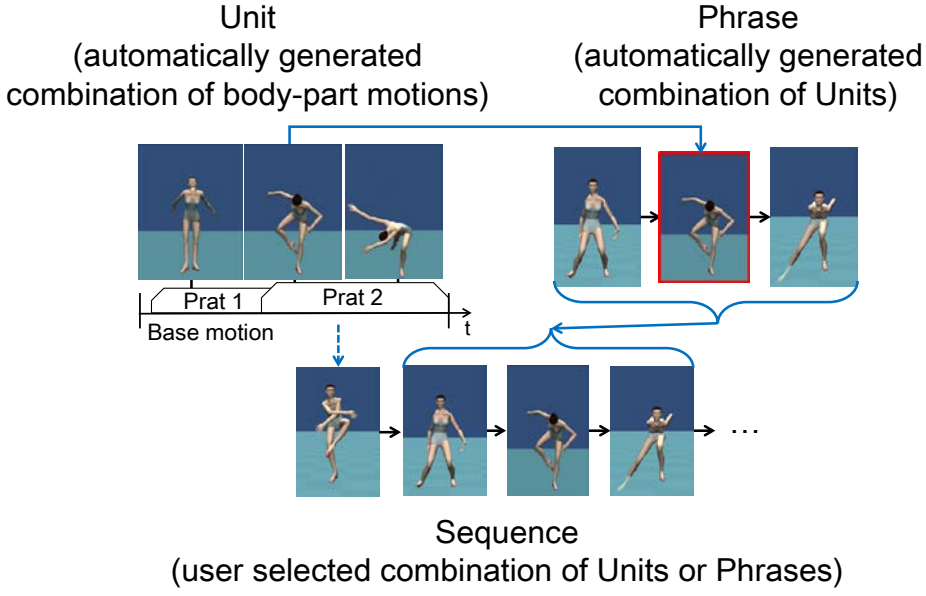

Figure 2. Examples of Unit, Phrase, and Sequence.

Users can use the composed Sequences as references for dance creation, learning, and training. Since the application runs on tablets, users can use it freely anywhere

when they are creating dance choreographies. This provides an opportunity to develop new ideas for choreography creation. Occasionally, impossible and/or unnatural dance motions are created, but users do not have to completely reproduce actual motions in the 3DCG characters. They can incorporate various arrangements and ideas in their generated motions without our application by adopting such techniques as horizontal inversion and devising motions for the hands and feet to simplify balance.

3. Automatic Synthesizing Methods

3.1. Motion data

Motions are provided as short motion clips that were captured by motion capture from performances by professional dancers. Each motion clip consists of simple and uncombined movements. Each motion's potential for synthesis is analysed and separated into three main categories: Base, Blend, and Body-part.

The motion clips of the Base category are the whole-body movements that form the basis of the created choreographic motions. Motions that involve the whole body, like standing upright or one-leg balance, are assigned to this group. The Base category includes the sub-categories such as Stand, Move, Jump, Turn, and Floor. The motion clips of the Blend category are the whole-body movements that can be blended with the Base motion clips. This group mainly consists of hip movements like jumping and twisting, that which are made more effective by blending them together with other motions. The motion clips of the Body-part category are the body-part movements that replace the body-part movements of the Base motion clips. The Body-part category includes the sub-categories of body parts, such as Body, L-Leg (Left-Leg), Shoulders, Arms, and Neck. Only L-Leg motions are prepared as the replaceable leg motions, since unnatural motions can be generated when both legs' motions are replaced. Moreover, during performance of the choreography, users can horizontally invert these leg motions to the right side. Figure 3 illustrates body-part categories. The number of motion clips included in each category is shown in Table 1. There are 167 motion clips in total.

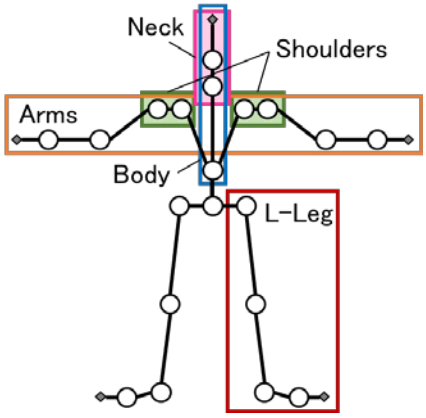

Figure 3. Body-part categories.

Table 1. Categories and the number of motions used in BMSS 4.1.

Motion category		Number of motions	
Base	Stand	20	60
	Move	12	
	Jump	10	
	Turn	6	
	Floor	12	
Blend			7
Body-part	Body	10	100
	Neck	10	
	L-Leg	26	
	Shoulders	8	
	Arms	46	
Total			167

3.2. Automatic synthesis of body-part motions

Figure 4 shows concept of generating Units. Short choreographic motions about five seconds long are automatically generated by synthesizing various body-part motion clips. In Figure 4, an Arms motion and a L-Leg motion are synthesized to the user-selected Base motion. Based on the motion categories selected by the users, body-part motions synthesized to the Base motion are selected and the synthesis timings are randomly determined. This feature allows countless variations of choreographies to be created each time.

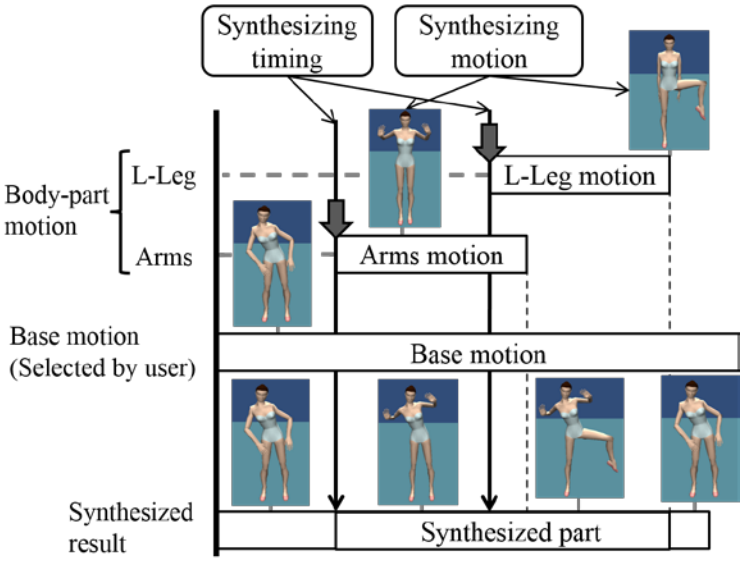

Figure 4. Concept of generating Units.

The motion clips that are used for the synthesis are automatically selected. First, it randomly determines the number of motion clips that are synthesized to the Base

motion clip based on the upper limit of the categories selected by the users. Next, the motion categories are selected from the Blend or Body-part categories. Then one motion clip is selected for each category. To show many selections and provide an opportunity to develop new ideas for choreography creation, ten Units are created at the same time. The same motion clips are not selected as possible in the ten created Units to avoid duplication and to ensure a certain degree of variety.

The synthesis timing of the motion clips is automatically determined. Perhaps impossible or unnatural motions are generated if the synthesis timing is simply determined by a random number. To reduce the chance of generating such motions, we adjusted the synthesis timing by the constraints of body parts making contact with the floor [6].

3.3. Automatic generation of Phrases

Our system supports the automatic generation of Phrases to investigate motion connectivity. The connectivity between saved Units is evaluated using the similarity of starting/ending poses included in each Unit, determined by the distance between connectable poses. Based on this idea, a few Units are connected that contain a pose that resembles the starting/ending pose of the Units entered by users. In our system, the generated Phrase consists of up to four Units at present. In addition, it randomly selects a connecting Unit from within a threshold's range to make variations. Figure 5 shows examples of the created Phrases. Based on the user-selected Unit in red rectangles, the system suggests the following or previous motions from the saved Units.

We propose a method that automatically synthesizes a sequence of motions by connecting choreographies based on the distance between starting/ending poses of motions, which would make it easier to consider the connectivity of choreographies. Based on this idea, a few choreographic motions that contain a pose that resembles to the starting/ending poses of the choreographic motions entered by user are connected.

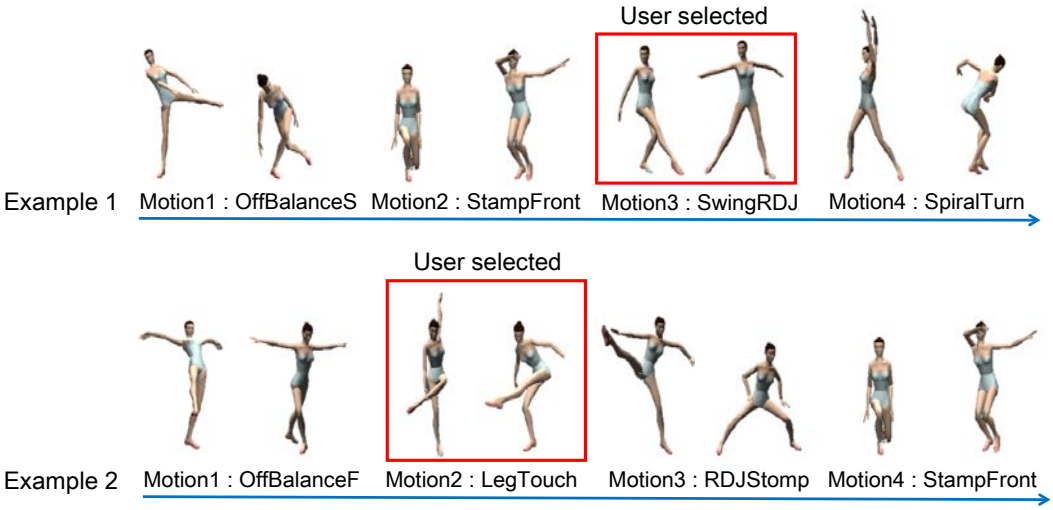

Figure 5. Examples of generated Phrases

4. Experiments

4.1. Method

We experimentally evaluated the effectiveness of supporting dance creation and our method's effectiveness of handling Phrases with eight University of Tsukuba students in Japan (JP) and seven University of California Irvine students in USA (US): 14 females and one male.

Our experiments were conducted by one set from two to four participants in a dance studio, and the experiment time per set was 90 minutes. First, we briefly explained our system to the students and they freely simulated and composed Units with the software. Second, they selected and saved around 20 Units that might have serve as seeds or hints of their own choreographies. Next, they created their own short, roughly 30-second long dance Sequences using the saved Units with two different methods: by hand or Phrases. After the students created their choreographies, they could freely add such techniques as iteration, inversion, or speed changes. They performed their choreographies themselves in front of a video camera, answered questionnaires at four levels and explained the reasons. We asked them the system's effectiveness for contemporary dance creation by two methods: hand and Phrases. We also got feedback about the effectiveness of understanding the movements and the training of dance techniques.

4.2. Results and discussion

The results of the four levels are illustrated in Figure 6.

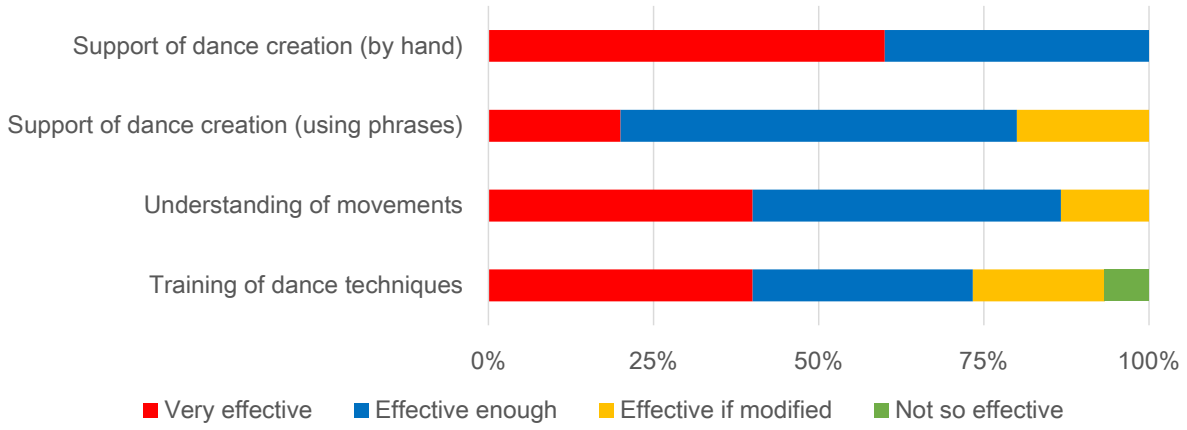

Figure 6. Evaluation by students.

All 15 students answered "very effective" or "effective enough" for contemporary dance creation by hand. None chose "effective if modified" or "not so effective". On the other hand, in terms of contemporary dance creation using Phrases, three students answered "very effective," nine answered "effective enough," and three answered "effective if modified."

By comparing these results, numerical analysis suggests that most students preferred to create Sequences by hand than using Phrases. The results indicate almost same tendency for students in Japan and US despite the difference of learning environments of contemporary dance. Several typical reasons are excerpted below. The student's country is shown in brackets: (JP) or (US). The Japanese responses were translated into English.

"I could imagine the connectivity of movements better by the hand method" (JP). "With the Sequence created by hand, it was easier to express by my actual body than using Phrases" (JP). Here are some positive reasons for using the Phrases: "[It] made new transitions I would have not naturally done and created repetition" (US), "it gives the new idea such as a way for a smoother transition in each movement" (US), "the time for creating with Phrases was shorter than by hand" (JP), and "it was easy because the flow of movements was just generated naturally by selecting a motion that I really wanted to input" (JP). The feedback suggests that our system effectively supports dance creation.

In terms of understanding the movements, 13 of 15 students (87%) chose "very effective" or "effective enough." We received the following comments: "Very easy to see dancer's movement on the screen," (US) and "some movements became hard to follow if the avatar was glitchy" (US).

In terms of training the dance techniques, 11 of 15 students (73%) chose "very effective" or "effective enough." Three answered "effective if modified," and one answered "not so effective." The main positive reason was that it "gives good practice sequences for outside of class" (US). The "not so effective" reason was that "some movements were hard to understand when it comes to a simple movement, it's easier to catch but in a harder one it's more difficult to understand the concept of the movement" (US).

5. Conclusion

We developed a system that creates short contemporary dance choreographies by automatically synthesizing many body-part motions to support choreography creation. We proposed a method that automatically synthesizes phrases by connecting choreographic motions based on the distance between the starting/ending poses of motions to simplify the continuity of choreographies.

We experimentally evaluated the effectiveness of BMSS 4.1 with 15 dance students at two universities in Japan and USA. The students created choreographies using the system and performed them. We gathered questionnaire comments about the system's effectiveness for creation, training, and understanding movements. Our experiment results confirmed that automatically generating choreographic motions and phrases effectively supports dance creations. We recognized that most students preferred to create sequences by hand than using phrases. However, using phrases increased the speed of sequence creation more than that by hand and sometimes suggested new connections of movements. We verified that BMSS is a helpful

creation training tool for dance students who can discover new choreographic methods, new dance movements, and greater awareness of their bodies.

In the future, we will give this system to professional choreographers and get additional feedback to improve it. Creating longer dance sequences and performing them on stage is another challenge. We will also archive additional motion clips and adapt our system to such dance genres as hip-hop or classical ballet.

Acknowledgements

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