Choreographic design visualization of enormous dancers for authoring and browsing dance motion and formation

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Abstract: In this paper, we propose a choreographic design visualizing enormous dancers' motion and their total formation. The system aims to not only intuitively preview the total impression but also improve the choreographic design before the real performance of the dancers. We focus on the simultaneous design of both the formation and motion to balance of the total view. Captured motion data by Kinect are obtained as fragments of dance influence. The choreographer first puts multiple CG dancers in a virtual space at the same time by drawing reference lines or equilateral polygons on 3D-coordinate and she/he browses the total view of dance motions from flexible viewpoints. Each motion is assigned to each correspondent group of the dancers based on multiple channels' time-lines. This configuration enables a smooth choreographic procedure for enormous dancers from the viewpoint of both detail and whole. Finally, we verified a) browsability and b) easiness of the formation design in our proposing authoring system.

Key words: Choreographic Design, Dance Motion, Kinect, and 3DCG

1. Introduction

Choreography is the art of arranging dance performances in detail with designing sequences of movements in which motion, form, or both are specified. Choreographers devise dance motions and formations so as to seem appealing, and they also need to instruct dancers how and when the dancers make motions and formations. In general, 1) choreographers first create some fragments of bodily motion. Next 2) they make motion sequence, and finally 3) they design the dancers' total formations based on motion sequences. Formation design is the most important but very difficult procedure in these steps.

In practical choreographic scene, choreographers show the performers each motion-sequence of the preliminary choreography, and instruct them to imitate the motions. However, it is often happened that the real performance shows worse view, differently from their first intention, or the imagination-based choreography causes some impossible situations. In particular, such problems often happen when there are more than hundreds of dancers. The problems are related to the shape of formation, the number of the dancers, the timing of their actions, and so on. Choreographers improve the design through a trial-and-error process with the dancers for many times in order to produce the better-balanced choreography. The process includes the problem of the limit in the dancers' physical strength. Moreover, the cooperative process has the limit of time and place. Thus, the final design of the choreography need resource of time, place, and physical strength of both the choreographer and the performers with repeated practices and trials.

There is a conventional method of the formation design using a whiteboard and magnets in order to image the total view of the performance without many trials for the formation improvement. Choreographers regard the

whiteboard as the ground viewing from the top and a magnet as a dancer in this method (see Figure 1). The magnets are arranged on the whiteboard for each performance scene as the choreographer's intention. The problem of this method is the difficulty of the kinetic imagination; choreographers can efficiently design only formations, but they must imagine the dancers' motion in the arranged formations for well-balanced choreography. This is because there are various complicated situations. For examples, there are many cases in where various motions are assigned to each appropriate formation group or in where the dancers perform the same motion with time lags as to make a wavy view. These are obviously more complicated and more difficult to imagine the total design formations with the larger scale of the performance and the larger number of dancers.

We have developed the choreographic design system for smooth imagination of enormous dancers' kinetic motions. The system consists of three part of the design process: 1) taking data on dance motion by Kinect Motion Capture, 2) visualizing the motion capture data in virtual space, and 3) designing formations by the anthropomorphic agent. In this paper, we propose this system and verify a) the *browsability* and b) the *easiness* of the choreographic design and dance motion.

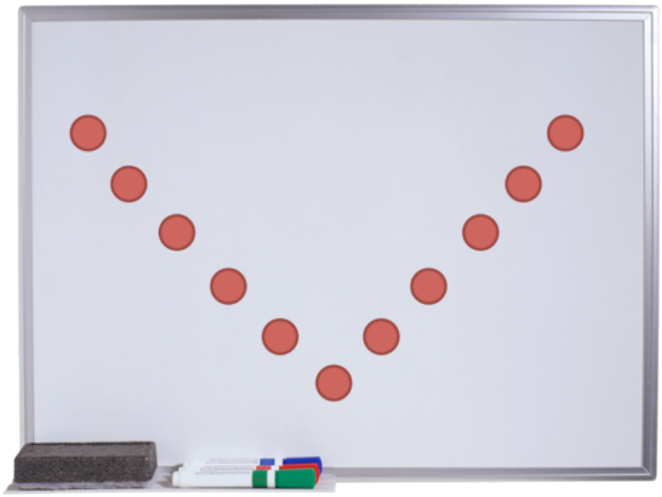

Figure.1 Conventional Method with a whiteboard and magnets

2. Related Researches

Kaiga et al. [1][2] developed an ethnic dance learning system with a magnetic motion capture method. The system focused on editing dance sequences. They named some frequent fragments of the recorded motions as "Labanotation [3-5]", that means the dancing score, in order to convenient use of the motion database. The user can edit dance motions by placing the dance notes on the time-line-based interface, and 3DCG animations are created when the user saved the motion sequence. Against their purpose, our approach focuses on the formation design. If the dance performances are produced only several people, each motion is the most important element. On the other hand, a large-scale performance consisting of enormous people needs not only the elaboration of each dance motion but also the totally balanced appearance by well-designed formations.

Soga et al. [6][7] developed an on-line choreographic simulation system for classic ballet using an optical motion capture system. They made a database of fundamental pas (steps) in classic ballet. This system enables to visualize motion capture data as 3D ballerina model, to preview fundamental pas with changing the speed, and to

edit motion data from a flexible viewpoint. This method leads efficient choreographic process for the motion rules of classic ballet; however, almost all of general dances have to input new and original motions additionally to some original motions.

Motion captures and their applications for dance performance have been had detailed discussions in this decade [8][9]. According to the progress of the capturing methods, there are a lot of commercially produced authoring systems for 3DCG Animation. In these years, free and high quality systems are provided on the Internet; for example, MikuMikuDance [10] is an application for creating 3DCG Character Animation by key-frame method for motion design in detail. However, it is difficult for novice users of 3DCG creation to manipulate these kinds of the applications.

Thus there are not any total choreographic design tools for numerous dancers focusing on formation still the performances need each total design. Consequently, we propose a choreographic design system with CG virtual dancers for her/his imagination of enormous dancers' performance with the processes of the motion acquisition, the motion arrangement (editing), and the formation control.

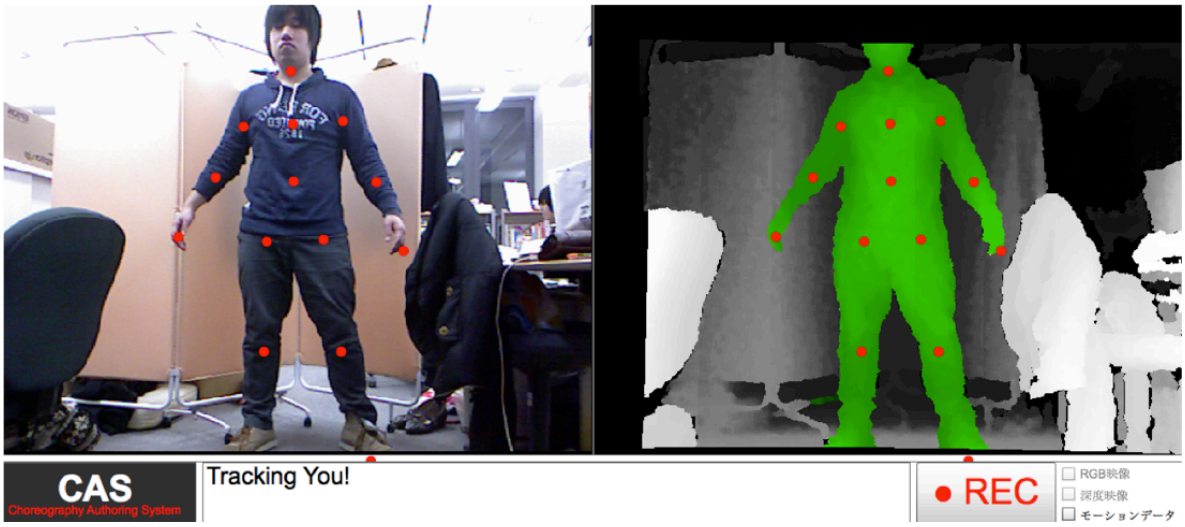

Figure.2 An Application for Inputting Motion Data from Kinect

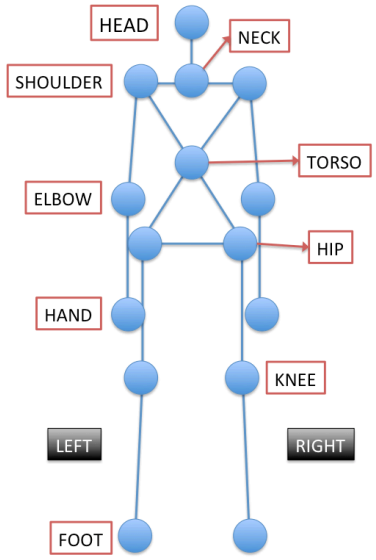

Figure.3 Skeleton Model of Human Body

3. System Structure

3.1 Capturing Dance Motion

In order to visualize various motions of virtual CG agents, we developed an original motion recording system using Kinect Motion Capture system as shown in Figure 2. The 3D coordinates of the 15 joints in a human body are converted into a line with a time stamp by a frame, and the time-series data of the fragment are exported into a text file (see Table 1). The system converts the camera-coordinate data into the world-coordinate data in order to naturally visualize the CG agent in a virtual space (see Figure 5). Figure 2 shows a model of the skeleton model as the real human body with 15 joints, which is a head, a neck, shoulders, elbows, hands, a torso, knees, and feet.

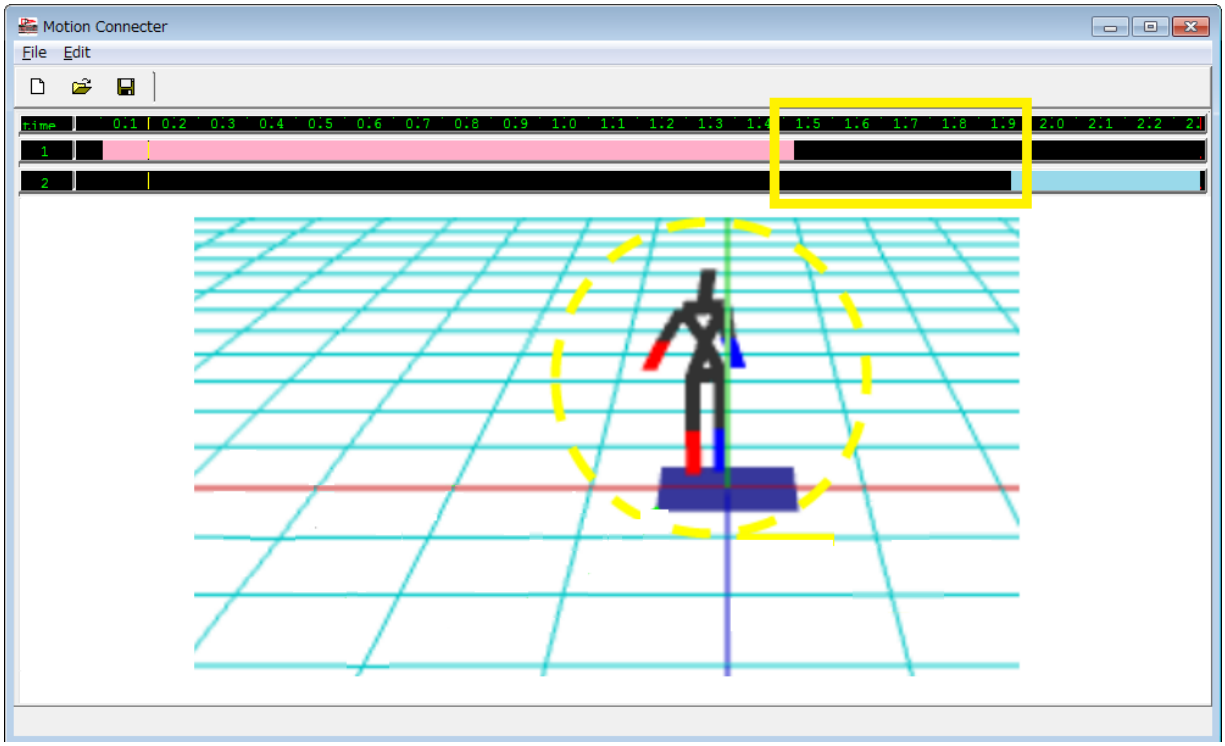

Figure.4 Interpolating the 3D coordinates of the motion fragments

3.2 Arrangement of Motion Sequence from Motion Fragments

There is no doubt that a long motion fragment can be treated as a motion sequence in the choreography. Nevertheless, it is necessary to provide an arrangement system of the motion sequence from multiple recorded fragments when choreographers need some new motion ideas or when they make mistakes when they record dance motions. We built an individual arrangement system of the motion sequence as shown in Figure 4. The multiple fragments can be put on the timelines. The system automatically interpolates the 3D coordinates of the motion for a short-term gap from the end frame of the first fragment to the first frame of the second fragment. This arrangement method enables to create a novel dance motion, which has not been designed by anyone else.

3.3 Choreography Authoring System

3.3.1 Design of Formation

We developed methods for designing formation by arranging dancer agents on virtual space. It enables to create formations of linear type and polygonal type like Figure 6, set another motions to each formations, and time lag in the formation with same motion.

3.3.2 Visually Arranging Motion Data on Timeline

In order to visually treat motion data, we implemented a method for visually arranging motion data as “Motion Clip”. The “Motion Clip” is an interface modeled on the concept of an interface “Video Clip”, generally used in video authoring applications. The “Video Clip” is a symbol of video data, and represents information of such as data’s length with a rectangle and so on. Users are able to move it left or right with PC’s user interface, and to arrange timing for starting to play video. In case of the “Motion Clip”, video data just are replaced by motion data.

The Users can use multiple motion data, in order to assign another motions to dancer agents and formations, and to let them dance with each time lag for the wavy motions of the total as shown in Figure 5.

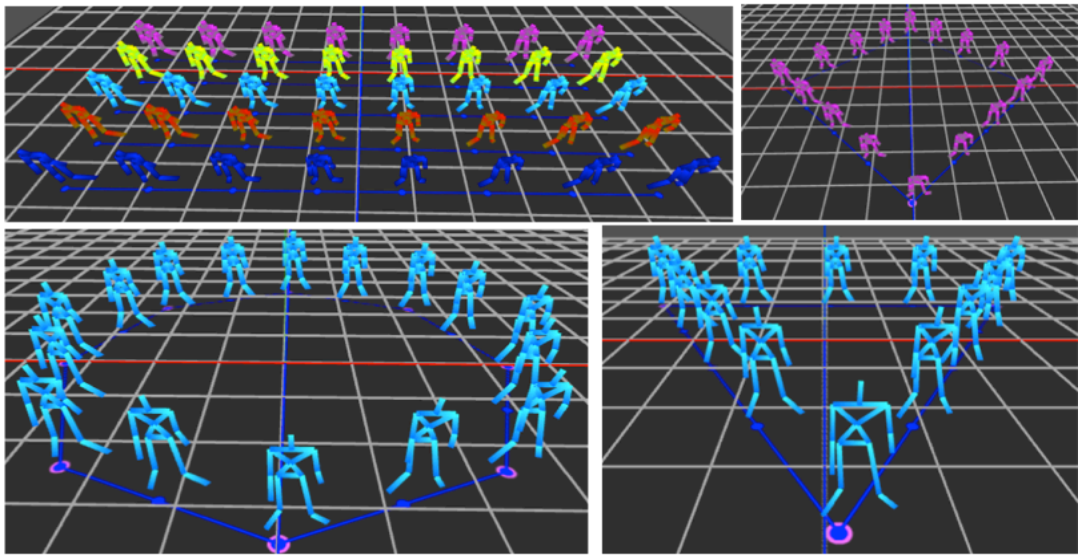

Figure.5 Examples of Designing Formation

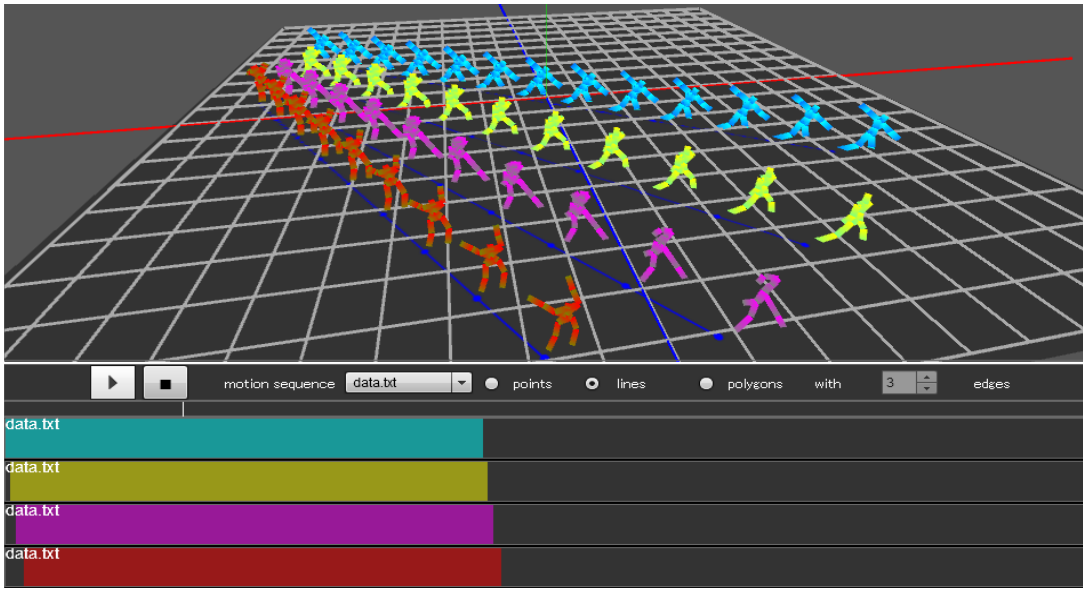

Figure.6 The Choreographic Design System

4. System Evaluations

4.1 Experiment 1: Evaluations of the Browsability in the Choreographic Design System

In this experiment we aimed to verify the browsability for the choreographic design focusing on the viewpoint's flexibility. We compared means opinion scores (MOS) for three kinds of browsing conditions.

Subjects: Twenty people aged early twenties (students of the Faculty of Informatics, no experience in choreography) participated in this experiments.

Methods: The conditions, containing three patterns of the viewpoint's flexibilities: browsing from A) only azimuth angle, B) only elevation angle, and C) azimuth and elevation angle, were evaluated in repeated measurements with a counter-balance. The subjects evaluated the conditions in relation to the browsability of the choreographic design on the five-level scale as follows; 5: relevant, 4: somewhat relevant, 3:even, 2: somewhat irrelevant, and 1: irrelevant.

Procedures and Conditions: To investigate the browsability of the motions and formations of the dancer agents, we compared three above conditions with different flexibilities of viewpoint. The subjects designed formations as he or she directed, and evaluated the browsability after each trial.

Instructions: The subjects were instructed how to operate viewpoints using a mouse device at first, and directed to design formations.

Results: Figure 5 shows the averages and the standard deviations of the evaluations for the browsability of dance formation. Table 1 shows the results of analyses of variance (ANOVA) with repeated measurement among the conditions at significant level = 0.05, and represent significant difference. The difference of the browsability's freedoms was significant (F (19)=37.948 and p <.01. The post-hoc tests also showed significant browsability of A) compared to B) and C), the significant browsability of B) compared to C)). Thus we found the browsability of the freedoms for flexible viewpoint can provide an intuitive view for the formation design. It is also conjectured that the viewpoint's freedom of the elevation angle is more important for the formation browsing than the azimuth angle.

Table 1. ANOVA: Result of Experiment 1

Evaluation of	F-Value	p-Value	Means on Factor A (Ryan's Method)
Browsability	37.948	**<.01** *	A-*-B A-*-C B-*-C

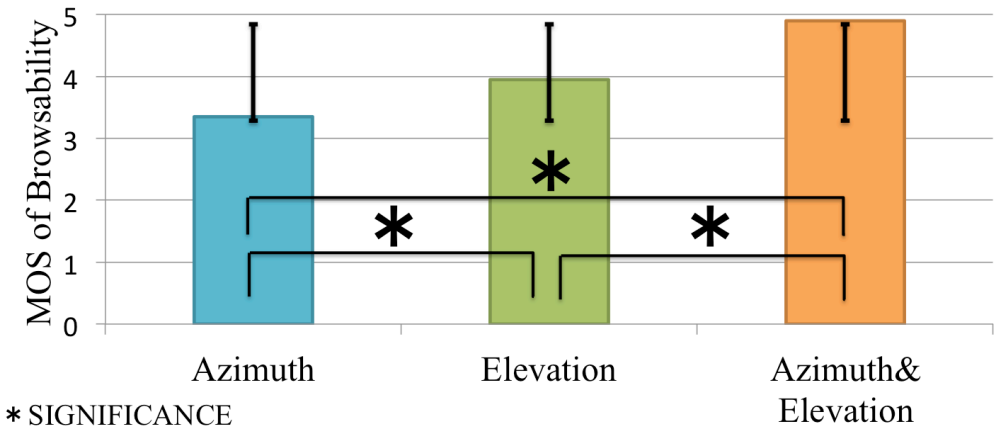

Figure.7 The Browsability of Choreographic Design [Experiment 1]

4.2 Experiment 2: Evaluation for Easiness of Reference Shapes for Formation Design

In this experiment we aimed to verify the easiness of the reference-shape based placing method of the dancers for designing formation. We compared means opinion scores (MOS) for four types of input methods as follows.

Subjects: Fifteen people aged early twenties who are the students of the Faculty of Informatics, without experience in choreography participated in the experiments. These people were different from Experiment 1's participants.

Methods: The methods of the formation design, containing four kinds of formations: A) transfer of each dancer agent, B) reference lines, C) equilateral triangle, and D) equilateral rectangle, were evaluated. The subjects evaluated the methods in relation to the easiness of the formation design methods on the five-level scale.

Procedures and Conditions: To investigate the easiness of the methods, we prepared a system each four methods were implemented.

Instructions: Subjects were instructed how to design formations and instructed to evaluate the easiness on the five-level scale.

Results: The results in this experiment are shown in Figure 8 and the results of ANOVA (significance level: 0.05) are shown in Table.2. The difference of the formation design easiness was significant (F (19)=15.607 and p <.01. The post-hoc tests also showed significant easiness of A) and B) compared to C) and D)). Thus we found the easiness of the simple reference shapes can provide an easiness of the formation design in this experimental configuration.

Table 2. ANOVA: Result of Experiment 2

Evaluation of	F-Value	p-Value	Means on Factor A (Ryan's Method)
"Easiness"	15.607	**< .01** *	A-*-C A-*-D B-*-C B-*-D A-**-B C-**-D

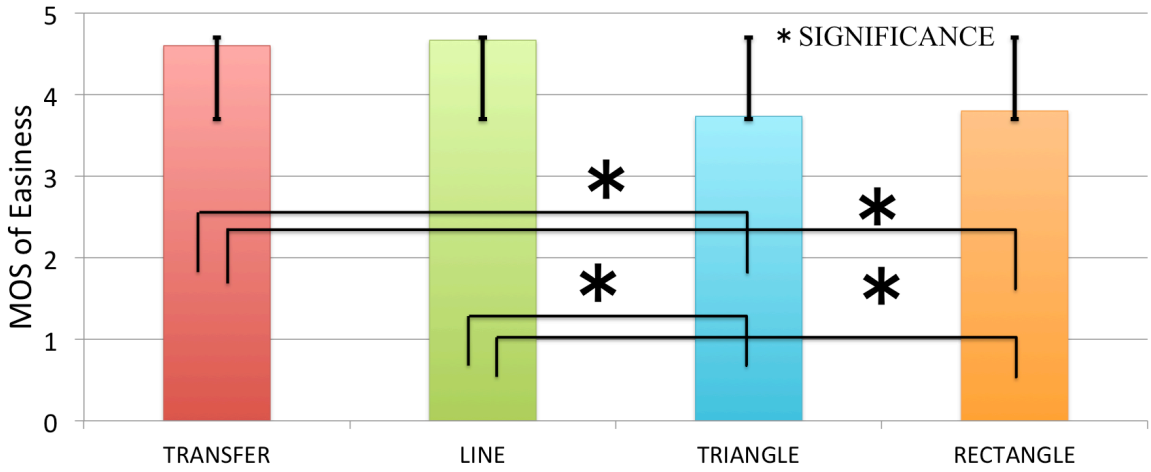

Figure.8 the Easiness Test of Formation Design Methods [Experiment 2]

5. Discussions

In the preliminary uses of the system in several demonstrations, we could confirm the creativity and the necessity of the dance-authoring tool for various types of performances by numerous people. As we focused on the browsability and the easiness of formation, we discuss the effectiveness in the following sections.

5.1 Browsability for the Choreographic Design System

The viewpoint's freedom of both azimuth and elevation angles showed significant browsability as we expected. There was an interesting result that the freedom of elevation angle was better than the freedom of azimuth angle. With the azimuth angle's freedom, the visibility of each dancer's motion became higher because of detailed observation from the front, back and so on; however, the difficulty of recognition is worse. On the other hand, the freedom of elevation angle highly scored than that of azimuth angle for evaluation of recognition. It is shown that the viewpoints include birds-eye view are very important to intuitively understand the formation of the dancers. Therefore, it is conjectured their weaknesses are cancelled each other by flexible viewpoint.

For higher browsability, the system should include not only the flexibility but also the easy interface. If the user has only common computer-user interface such as mouse, it should be also effective to provide a simple prompt of the actual state of the viewpoint based on the purpose: the formation design, the browsing of the total view, or the observation of individual dance motion. The continuous recognition of the user's browsability by the system would be helpful to provide an appropriate browsing style for each individual.

5.2 Experiment 2: Evaluations for Easy Formation Design

The results of A) mean the placing of the dance agent without reference by each time. A) and B), which is the usage of a reference line, were selected in case of the subject needed a flexible formation, and C) and D) were used in case of equilateral formation. We first presumed that the preset of the reference shape can help the formation, however, the subjects preferred to design by simple reference lines or put the dance agents without references. Thus, it is suggested that the flexibility of the formation design is important in this configuration.

In order to effectively adopt the reference shape in our formation design system, we should consider the flexible presets of the reference shapes, that is, the user-defined reference shapes. In addition, we should gather the shapes of the formation by their frequencies and the target fields.

5.3 Summary of Discussions

We could confirm the basic helpfulness and needs of use in the demonstrations. It is important to assure the browsability and the easiness of the formation design for smooth design of the formation. For both of them that are browsability and easiness of the formation design, it is necessary to aim the fewer procedures and the intuitive understanding by an appropriately visualized view. The choreographers using the proposed system should be expected to design higher performance of the total view with awareness of the individuals at the same time.

6. Conclusions

In this paper, we proposed a choreographic design system visualizing enormous dancers' motion and their total formation. The system aimed to enable the choreographer's smooth imagination of the total kinetic view of enormous dancers' motions. We verified the browsability and the easiness of the formation design using our proposed choreographic design method. In the results, we found that the browsability of the freedoms for flexible viewpoint can provide an intuitive view for the formation design, and that the easiness of the simple reference shapes can provide flexibility of the formation design in the configuration of Experiment 2.

As future work, we plan to implement our methods for creating more intuitive browsability and more flexible design of the formation in order to achieve more original, ideal and complex constructions of the choreographic

design. In addition, we plan to develop and evaluate notifying methods to choreographers about the difficulty in the realization of a choreographic idea with an interactive choreographic design.

7. Acknowledgements

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