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A Study on Image Expressions for Augmenting Street Dances and Their Matching

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Abstract

Recent years have seen lively combination between dance performances and video images. Such combination includes cases conducted through close cooperation between dancers and video artists and projection of images generated automatically in response to a dance. From the latter of these two perspectives, the authors are studying video projection intended to augment the appeal of dance performance. This paper reports on two types of image expression and a projection system intended to augment the appeal of three types of street dance—break dance, lock dance, and pop dance—and knowledge related to their compatibility, obtained from multiple attempts to augment the appeal of dance.

1. Introduction

In many cases the impression given by a dance performance on a large stage will be weaker than that of a dance viewed up close in more narrow confines. For this reason, in recent years it has become common to project video on the background behind the dancers in order to generate more of a stage effect like the performance of Perfume at the Cannes Lions International Festival of Creativity [1, 2, 3, 4]. Such efforts include productions made through close cooperation between dancers and video artists and projection of video generated automatically in response to the dance. The authors are studying video projection intended to augment the appeal of dance performance from the latter of these two approaches.

However, dance comes in various and diverse types, including street dance, folk performances, and contemporary dance. Development of a general-purpose image expression and projection system must start from study at a basic level of image expression that has an affinity to each type of dance.

As the subject of this study, focusing on break dance, lock dance, and pop dance as three subgenres of street dance, this paper reports the development of two types of image expression systems for responding automatically to the movements of dancers and experiential knowledge obtained from studying the affinity between these systems and each genre. Regarding this study, we reported early trial in [5], and the latest result in [6] so far. In this paper as an extended version of [2], we will describe the detailed information of our image expressions and give the conclusive estimation of their augmentation effects.

2. Related studies

2.1 Video projection in performances

While there are many cases of projection of video images in performances, few papers have been published on the subject. Cases of video projection in performances can be grouped into the following categories.

I. Non-interactive video prepared in advance [7, 8, 9]
II. Interactive video generated in real time
(A) Video generated using wearable sensors, computers, etc. [10]
(B) Video generated using noncontact sensors such as cameras [11, 12]

Type I makes possible performances in which the dance and images closely match each other. For example, in the case of "Leptoner" by SHIRO-A [7], repeated practice has resulted in a close match between the dance and the music and video prepared in advance.

Type II-(A) is highly interesting in that it employs advanced technology.

This study will employ a method of using equipment capable of analyzing the movements of dancers without having them wear any special equipment, to avoid interfering with the dancers' performance. As such, it will take the approach described under Type II-(B).

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2.2 Augmented performance

Like this study, the study "Augmented Performance in Dance and Theater" by MIT Media Lab [11] employed method II-(B). It can be described as a revolutionary study of performance augmentation, one that defined the term "augmented performance."

That study proposed "Dance Space" as a system intended to augment dance. Dance Space augments performance from the two aspects of audio and video. As audio augmentation, it is capable of generating audio in response to the dancers' movements, linking virtual musical instruments to each of the body parts of the dancers. As video augmentation, it draws colored Bézier curves in sync to the movements of the dancers, tracing the movements of their body parts and expressing characteristic movements.

That paper describes attempts at various types of augmented expression using advanced technologies. But it does not consider the affinity between image expression and individual dance genres such as street dance.

3. Concepts of augmenting expression

3.1 Positioning of dancers and background video

The image expression used in this study is generated automatically to augment the expression of the dance in response to the dancers' moves, rather than having the dancers generate video images themselves using video tools.

In order to build the basic technology needed, we prepared two image patterns for the image expression in this study: image expression reflecting the movements of dancers' whole bodies and records of their movements, and image expression triggered by the momentary movement of a single body part. The purpose of this approach was to study the affinity between characteristic street dance and image expression.

3.2 Objects for augmentation

In this study, we decided on objects for augmentation as the three subgenres of street dance: break dance, lock dance and pop dance. Characteristics of these dances are described as below:

- Break dance

Break dance can be defined by the dynamic movement of the whole body. The characteristic movements include "entry," in which a dancer stands without touching the ground, "foot work," in which a dancer spins around his or her legs while centering his or her body with the hands touching the ground like a pair of compasses, and "power moves" in which a dancer makes acrobatic movements swirling the whole body or jumping dynamically. They also include "headspins," in which the dancer swirls the body while standing on his or her head.

- Lock dance

Lock dance can be defined by the movement in which a dancer moves and stops his or her hands and feet quickly. This dance was named "lock dance" because the dancer seems to be locking by these movements. Characteristic movements include "Point," in which the dancer raises his hand and points in one direction. In lock dance, the dancer makes a little sideways movement.

- Pop dance

This dance includes movement in which the dancer "pops" his or her muscle and movements involving slow motion and mechanical movements like robots.

3.3 Image patterns

Next we will describe the concepts behind the two types of image patterns employed.

3.3.1 Image expression "Track" focused on the silhouette

Expression using the silhouette of the dancer is one conceivable method of expressing the movements of the body as a whole (Figure 1). We call this type of image expression "Track" because it's visual feature is the time series of dancer's silhouette.

The silhouette is a design that traces the contours of the human body, filling it in with a single color. In still image expression it is used for purposes such as concealing or omitting the details of the human form. It is conceivable that when we track the dancer's movement in chronological order, we can see the changes of the dancer's whole body posture more clearly by seeing the dancer's image as silhouette than expressing such movements without omitting minor details.

The Palindrome's "Shadows" [13] is one example of augmented expression of dance using silhouettes. It aims to express the shadow isolated from the dancer him or herself through means such as holding only the silhouette still while the dancer is dancing and depicting the silhouette moving at a timing that differs from that of the dancer. It differs in intent from this study, which aims to augment expression by emphasizing an impression that the video and the dance are one performance.

The silhouette pattern used in this study follows continuous changes in the dancer's movement by raising, above the dancer, a silhouette depicting his or her immediately preceding move. Connecting such images together makes it possible to depict a continual trace of moves that could only have been seen momentarily as they occurred without the effects of video.

One problem in raising the silhouette above the dancer is the fact that when the dancer does not move much to the left or right the image could be concealed behind him or her. To avoid weakening of the impression of the performance as a whole due to concealment of the background image, we projected a reverse image of the dancer's silhouette onto a space not blocked in this way by the dancer, with the dancer positioned to the left or right of the stage. These both connected the image to the dancer's movements and avoided a situation in which nothing would be visible in the background.

Also, to express changes in the video image using a silhouette, we

prepared patterns such as ones in which the silhouette was filled with a single color, nebulous patterns, and grainy patterns, switching among these in connection with major changes in movements within the dance.

The main colors we used in the images were bright yellow and greenish-yellow, a color that matched the yellow well. At times of major changes in movements we changed the colors of the silhouette to red, which calls to mind intensity, and purple, which matched the red well.

Figure 1. Image expression "Track" focused on the silhouette

3.3.2 Image expression "Flash" focused on hand movements

One conceivable way of emphasizing the movements of detailed body parts such as the hand would be to add images in which objects form or appear from the dancers' hands, so that viewers' lines of sight would be attracted to that body part even when viewed from a distance (Figure 2). We call this type of image expression "Flash" because in this image expression, particles of light and lightning bolts appear.

In this study, the object formed from the dancer's hand consisted of particles of light and beam of lightning bolts. We decided to generate particles of light because we believed that the image of the light, which evokes high technology, would fit well with the contemporary image of street dance and that it would make it possible to create an image having a strong impact, like floating in outer space, by arranging star-like particles of light of random sizes on the background.

To reflect the dancer's movements, the colors of the particles of light changed depending on the point where the dancer's hand started to move. Also, since if they flew in a single direction they would seem artificial in comparison to the natural moves of the dancer, we decided to use movements in which the particles would fall naturally downward.

We believed that the beams matched the image of outer space created by particles of light and that perhaps they would make image expressions more easily acceptable to viewers since they incorporated natural phenomena along with the force of gravity on particles of light.

Figure 2. Image expression "Flash" focused on hand movements

4. System overview

Since this system was intended to generate video images suited to the dance while enabling the dancer to continue to concentrate on his or her performance, it did not provide monitors on which dancers could check their own background videos. In consideration of the need to recognize movements and output background video both in real time and of the fact that it would be preferable if both dancers and viewers were not conscious of the equipment used, we developed the system as outlined below.

We used Kinect to obtain data on dancers' movements. A Kinect device combines features such as a depth sensor and a red-green-blue camera into a relatively compact size. For this reason, it is hard to notice even when placed right in front of the dancer. We hung a piece of cloth behind the dancer as a screen, employing rear-screen projection in which the projector projected images from behind. The traditional method of projecting from a projector in front involves problems such as light that shines directly into the dancer's eyes and the dancer's shadow blocking part of the background image. The system also needed to project the image over a wide area of the screen in order to match the energetic movements of the dancer and the size of the stage. Accordingly, we used multiple projectors. We set up a screen that was broad in size both horizontally and vertically, by using two to three pieces of cloth about five meters high, lined up horizontally. Figure 3 shows the structure of the system. To make the dancer visible even in a dark space, we shined moving lights on him or her from two directions: from the dancer's feet and from his or her side.

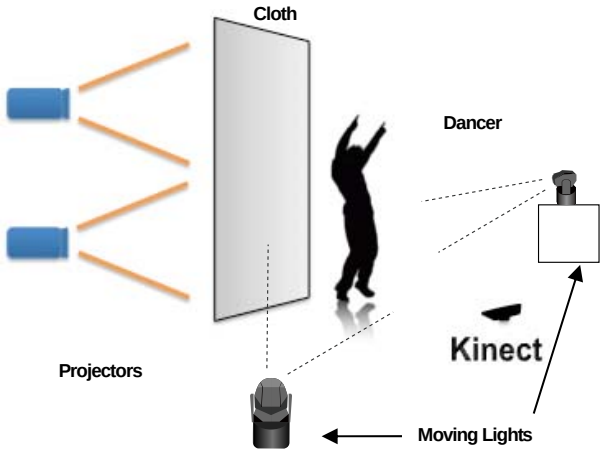


Figure 3. A dancer and system equipment

5. Video generation

5.1 Video generation of "Track" focused on the silhouette

(1) Steps of video generation

To generate video focused on the silhouette, we created images based on data on the dancer's silhouette and depth data available from Kinect (Figure 4). We used this data to change silhouette patterns and determine the effects to apply to the images in addition to creating the form of the silhouette itself. The flow of silhouette generation is outlined in steps i- iii below.

i. Obtaining the silhouette from Kinect

Kinect's ability to detect a human being and output his or her silhouette is used to obtain the data on which the generated images will be based. When generating a granular silhouette, one of the silhouette patterns, its resolution is determined through a tradeoff with the speed of computation.

ii. Silhouette generation and analysis

Depth data is analyzed at the same time as generating the silhouette. The method of generating the next frame and composing frames are determined, and preparations for applying stage effects are made. Effects and their timing are determined based on the gradient information of a depth image and on the depth distribution. Since depth data is scanned in both silhouette generation and analysis, conducting both these steps at the same time is more efficient.

In addition, at this time generation of the figures to be used in the next frame begins, based on the values obtained in this step, as a separate thread from image generation.

iii. Applying stage effects

The stage effects are applied in accordance with the state of the dancer's body, based on the results of analysis from step ii. For example, when the dancer's body leans to the left or right the output image will lean in the opposite direction, and when the dancer stops moving the silhouette will be cloned.

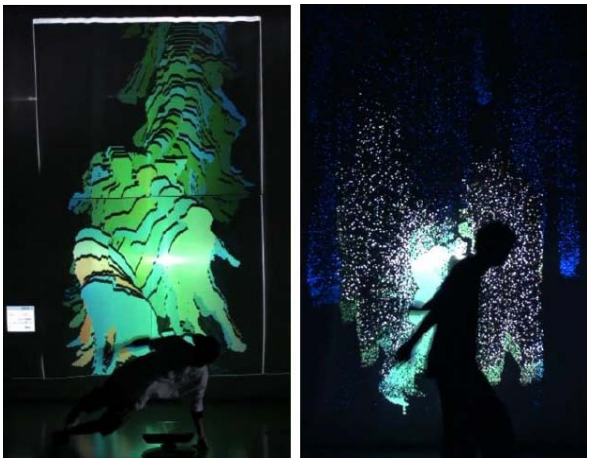


Figure 4. Image generation examples of Video generation of "Track" focused on the silhouette

(2) Silhouette patterns

In generating this silhouette, silhouette patterns are created using multiple methods. Those considered to have been useful as stage effects as a result of trials can be broken down into the following three general patterns.

A. Nebulosity, granularity (Figure 5)

When the dancer's silhouette has been identified through scanning depth data, the color and coordinates for image generation are obtained. Then, these are used as pointers for the output image.

Here the output image is derived by scanning depth data to determine the area of the dancer's silhouette and through random sampling of pixels in that area. Random noise generated by FFT [14] is used in this random sampling.

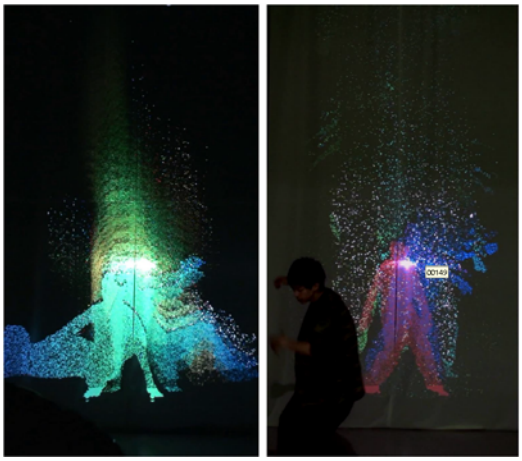


Figure 5. Image generation examples: nebulosity (left), granularity (right)

B. Contour emphasis (Figure 6)

The effect of emphasizing the silhouette's contour can be obtained by filling it in with a single color. Here, the silhouette's contours are simplified first. This is because since the contours of

the basic silhouette obtained from Kinect are too rough, if the contour is emphasized without smoothing then this rough pattern will become too apparent. Next, the upper edge of the silhouette is extended upward.

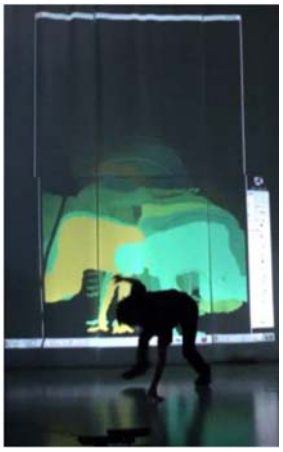


Figure 6. Image generation example: contour emphasis

C. Light flame

This image generation method overlaps multiple silhouettes each time the image is refreshed. The result is a light flame effect (Figure 7: left). Since it can be difficult to see depending on stage brightness, coloration, and other conditions, we also prepared a pattern that would display the contour more clearly by adding noise (Figure 7: right).

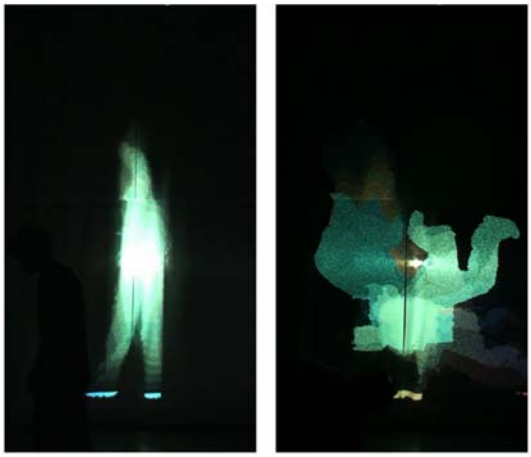


Figure 7. Image generation examples: light flame (left), light flame with noise (right)

(3) Stage effects of silhouette

The conditions and content of stage effects of silhouette are described below.

A. Left-right reversal (Figure 8: left)

When the dancer's body inclines left or right to at least a certain degree, the silhouette is output inclined in the opposite direction. This reversal effect expands movement horizontally by displaying a background image in the space left empty by the dancer.

B. Silhouette cloning (Figure 8: right)

This effect gives the appearance of the silhouette cloning as copies of it are displayed to the left and right of the dancer when he or she stops moving temporarily. This is intended to emphasize the impression made by trademark poses in the dance.

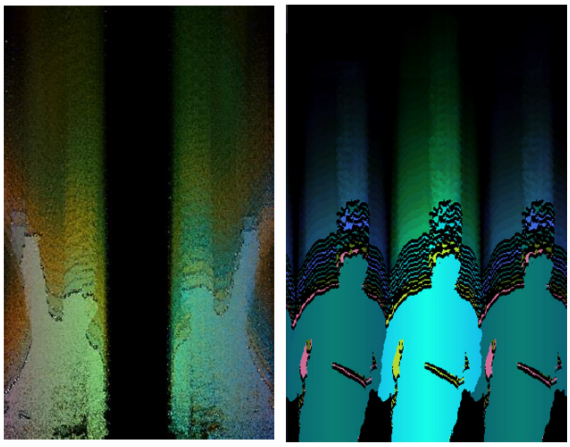


Figure 8. Reversal (left), silhouette cloning (right)

C. Background color change (Figure 9: left)

This effect changes the background color to white or black. It is changed when the dancer moves on slow movement after a series of energetic movements. This makes it possible to emphasize the change in the dance situation and lend variety to the images.

D. Silhouette pattern change (Figure 9: right)

While ordinarily the next silhouette pattern is determined when generating a silhouette, when the dancer's body has rotated to the left or right a certain number of times the silhouette switches temporarily to a nebulous or granular pattern. This is intended for use mainly with the break dance movement included in "power moves," in which the dancer rotates his or her body with body parts touching the ground, for example "headspins," in which the dancer rotates his or her body in an upside-down position, with the head on the floor, and a "backspin" or "shoulder spin," in which the dancer rotates the body centering on his or her back or shoulder.

Figure 9. Background color change (left), silhouette pattern change (right)

E. Silhouette color change (Figure 10)

When using a pattern such as light flame or contour emphasis for which no color is specified when generating the silhouette, this effect changes the color of the next silhouette generated, for use with continued movements such as holding hands together or pulling the arms on his body. It also is used with large steps to the left or right.

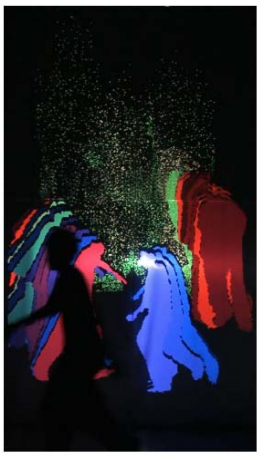


Figure 10. Silhouette color change

5.2 Video generation of "Flash" focused on hand movements

(1) Process of generation of particles of light

We designed the system to collect data on the dancer's hand movements and scatter particles of light in the direction in which he or she extends an arm. Controls of particles of light are explained in detail below.

i. Drawing the particles of light

The particles of light are generated on a four-sided plane with dimensions measured in X and Y coordinates (a billboard). This was done for purposes of reducing the computing load required and to apply textures in later processing. Each particle is formed of two planes: one showing the central light and one showing the surrounding color. The superimposed portions of the particle express light through use of an additional blending effect that amplifies the brightness (Figure 11: left).

Particles are given texture by loading partially transparent PNG image files (Figure 11: right). Colors are added to these and blended. The particles' expression of light is given diversity by combining multiple types of particles together, such as those of differing sizes and lengths.

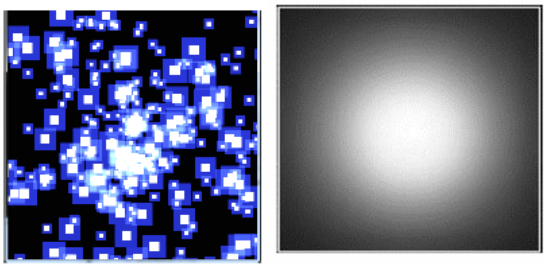


Figure 11. Blend effect on light particle (left), particle texture (right)

ii. Successive calculations of position, speed, and acceleration

Calculations are made in accordance with the moves of the dancers. The initial velocity is oriented in parallel to the direction of the movement of the dancer's hand, and it accelerates in proportion to the speed of movement. Actually, to give some randomness to the initial velocity it is multiplied by a noise factor generated using FFT. These calculations with Euler integration cause particles of light to move as the frame advances (Figure 12). Also, in consideration of gravity, each particle of light has been assigned a mass, making it possible to give some diversity to the movements of objects through means such as making some particles scatter more quickly and making some move like fireworks by changing their mass parameters.

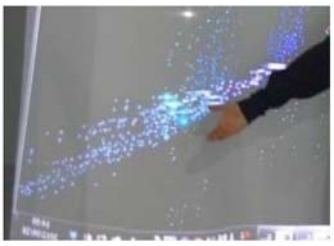


Figure 12. Particle movements

iii. Expression from generation through disappearance

The disappearance of particles of light is controlled using their α value (transparency: 0-1). When a particle is generated its initial α value is 1, and as its α value decreases the particle appears to dim and then disappear. A particle is erased from memory when its α value reaches 0 or it moves out of the area depicted in the image. By assigning frame numbers at the same time a particle is generated, the system makes it possible to decrease the α value by a designated value after reaching a specific frame.

(2) Process of generating beams through discharge of electricity (Figure 13)

This type of effect is generated around the dancer's hands. It is generated when the Y coordinate of the dancer's hand rises above the Y coordinate of the dancer's head by at least a certain speed.

Figure 13. Beams through discharge of electricity

6. Test trials

In the testing stage, we improved the system based on the responses of dancers and audience members.

(1) Responses from dancers

Dancers reported that they were able to concentrate on dancing without being distracted by how the images appeared. From this result, it can be said that the system for automatic generation of background images developed in this study can be expected to be useful.

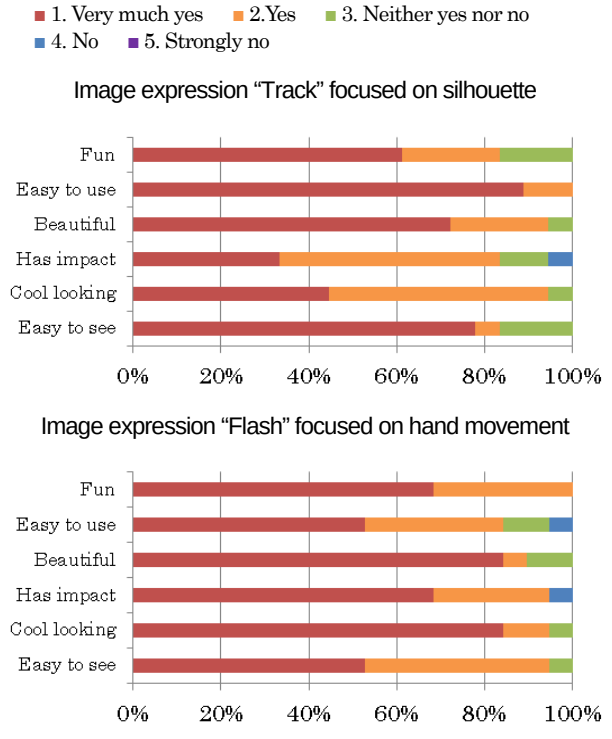
(2) Responses from audience members

We set up demonstration booths where visitors to the event of Art & Technology Tohoku 2013 could experience this system on a small scale and collected their impressions of this experience.

Table 1 shows the results of surveying these 19 visitors (18 in the case of generation pattern A, since one did not reply).

Table 1. Trial survey findings

Question: Please rate each pattern generated on the following items, on a scale of one to five.



From this questionnaire we were able to obtain positive evaluations from more than 80% of subjects on all assessment items for both patterns generated, as a result of their experience in the demonstration booth. When we asked the subjects if they had any dance experience, only two of the 19 answered in the affirmative. From these findings, this system can be considered something that even people not highly familiar with dance would feel positive about and would use.

At the same time, we showed subjects a video of a performance using this system and collected their impressions. Many of their responses were positive, and some noted that the performance seemed interesting and made dance seem more attractive.

7. Consideration of demonstration findings

Following some improvements made in testing, we had two dancers conduct a demonstration. We had the dancers dance three genres of street dance: break dance, lock dance, and pop dance. Findings based on consideration of the affinity of each image to each type of dance are discussed below.

7.1. Affinity to image expression "Track" focused on silhouette

(1) Break dance (Figure 14)

Characteristic movements in break dance include dynamic moves involving movement of the entire body and the "headspins" move of rotating while standing on one's head as noted in 5.1.

In image expression "Track" focused on silhouette, the more changes of the dancer's movement take place, the more time-series changes can be seen in projected images. It results in images with impact. For this reason, image expression focused on silhouette can be said to be well suited to break dance.

We also were able to confirm that the following two points in particular had beneficial effects on break dancing.

● Changes in background color

Changes in background color were able to emphasize changes in movement of the whole body, such as shifting from slow movement to vigorous movement.

● Left-right reversal

Since break dance involves major movement of the entire body, it includes moves in which the body inclines to the left or right. Use of the effect of left-right reversal of the silhouette with such moves was able to make the performance appear more attractive than if there were no image in the background.

Figure 14. Break dance in image expression "Track" focused on silhouette

(2) Lock dance (Figure 15: left)

Lock dance involves frequent detailed movement of the hands and feet, with little movement of the entire body. For this reason, the silhouette does not change much, and the only effect of image expression focused on silhouette was that of projecting a simple silhouette above the dancer.

(3) Pop dance (Figure 15: right)

While pop dance does involve movement to the left and to the right, often these are slower movements than in break dance. And there are characteristic movements of dancer with little movements like robot or frame advance of animation with jumpy moves. For this reason, the silhouette does not change much in shape over time and it was not possible to derive effective results from image expression focused on silhouette.

Figure 15. Lock dance (left) and pop dance (right) in image expression "Track" focused on silhouette

7.2. Affinity to image expression "Flash" focused on hand movement

(1) Break dance (Figure 16)

In break dance, the dancer often moves his whole body dynamically and his hands move all directions. So in the pattern of particle, particles flied in all directions too associated with his hands' movement and the background image seemed disorderly. About beams of discharge, they appeared when the dancer raised his hands at moment, but he shifted forward next movement immediately so the connection between beams and raised hands seemed difficult to understand in break dance.

Figure 16. Break dance in image expression "Flash" focused on hand movement

(2) Lock dance (Figure 17)

On-and-off movements in which the dancer moves his or her hands and feet and then stops them like locking characterize lock dance. For this reason, use of this image expression resulted in an effect in which particles of light were generated by movement of the hands and then followed the hand as it stopped. It is thought that this made the hand movements more impressive as the particles of light flew out from the hands. In addition, the effect of beams from discharge of electricity was able to emphasize the lock dance move known as a "point," in which the dancer raises his or her hand high and extends a pointed finger.

Figure 17. Lock dance in image expression "Flash" focused on hand movement

(3) Pop dance (Figure 18)

Pop dance includes moves in which the dancer moves his or her hands and feet slowly and mechanically. By leaving a trace of this hand movement in particles of light, we were able to emphasize the fact that even though each individual move was substantially separated in time from the other moves they were connected in a series of moves as shown by the trace.

Figure 18. Pop dance in image expression "Flash" focused on hand movement

The augmentation effects of the two types of proposed image expressions against three kinds of street dances can be summarized in Table 2.

Table 2. The augmentation effects

	"Track"	"Flash"
Break dance	◎	△
Lock dance	×	◎
Pop dance	△	○

◎Considerably effective ○Effective △ Slightly effective ×Almost no effect

8. Conclusion and future topics

In this study we developed two types of image expression for street dance and considered the affinity of each image pattern to break dance, lock dance, and pop dance. Aiming to develop a general-purpose system in the future, we would like both to put to use the knowledge obtained from this study and to seek out a route toward applying it to a broader range of dance, including traditional performances such as Noh and classical ballet. As topics to address in the future, we would like to expand the possibilities of this system to a broader range of expression, for example by incorporating techniques for the simulation of fluids and rigid bodies and enabling dancers to influence the background more for example effects as if he can touch generated objects. As future improvements in the system, we are interested in the following points:

- Consideration of improving the accuracy of capturing motion and video generation by introducing a small-sized, lightweight and wireless acceleration sensor.
- Consideration of a projection method that can resolve the limitations of stage equipment without using a rear screen. An example would be projection from an oblique direction from a dancer, using the tool of deformation of the video that is used for projection mapping.
- Consideration of the possibility of improving the effects as an augmentation of expression by enabling dancers to control the video triggered by subtle movement like gripping and opening hands, by introducing a leading-edge sensor like Kinect V2.

Acknowledgements

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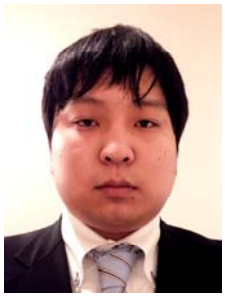

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