Evaluation on Performer Support Methods for Interactive Performances Using Projector

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ABSTRACT

Recently, performances that combine performers' actions and images projected from a projector have attracted a great deal of attention. In such performances, since the performer usually faces the audience, it is difficult for him/her to watch the projected images on a background screen. This means that he/she cannot make the performances dynamic in response to changes in the situation. Therefore, we evaluate multiple information presentation methods for interactive performances. We have developed a prototype system for supporting performers and evaluated its effectiveness. We confirmed that differences in display devices and in the types of presenting images affected the quality of performances. The implemented prototype was actually used in several stage performances, and we confirmed that the system was effective and improved the visibility of projected images.

Categories and Subject Descriptors

J.5 [Computer Applications]: Arts and Humanities; H.5 [Information Interfaces and Presentation]: Miscellaneous

General Terms

Experimentation

Keywords

interactive performance, projector, media art

1. INTRODUCTION

There are many styles of stage performances using computer technologies, for example dance performances that play music based on the dance steps using motion recognition techniques[1]. In particular, stage performances that are enhanced by visual images such as EffecTV[2] have attracted a great deal of attention. Recently, in addition to these performances, performances that combine an existing performance with projected images have been presented on stage to enhance the expressiveness of the performance, as shown in Figure 1. However, since the performer generally faces the audience, it is difficult for him/her to watch the projected images on the background screen. This means that he/she cannot make performances dynamic in response to the changing situation. Therefore, the goal of our study was to construct a system to support performers using display devices. We implemented a prototype system using a head mounted display(HMD) and evaluated its effectiveness by investigating in detail the visibility of display devices in various situations. Moreover, we actually used our prototype system on stage and confirmed the effectiveness of the proposed method.

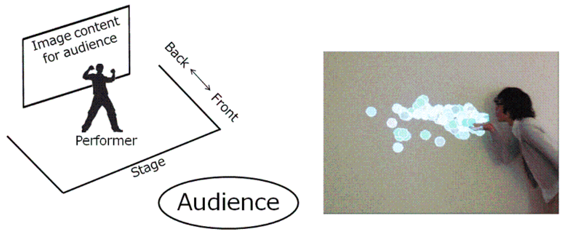

Figure 1: A performance with projected images

This paper is organized as follows. Section 2 discusses related work, and Section 3 describes interactive performances with projected images. Section 4 explains the system design. Section 5 explains an experimental study, and Section 6 describes the use of our system in an actual event. Finally, Section 7 is our conclusion.

2. RELATED WORK

In the field of entertainment, many performances are interactive and use computer technology, such as dance per-

MoMM2009, December 14-16, 2009, Kuala Lumpur, Malaysia.

Figure 2: Performance facing the audience

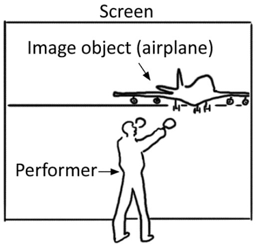

Figure 3: Performance facing a screen

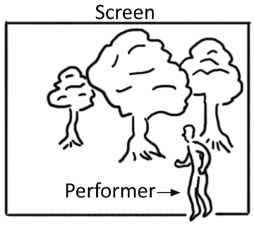

Figure 4: Performance in parallel with a screen

Figure 5: Performance in contact with a screen

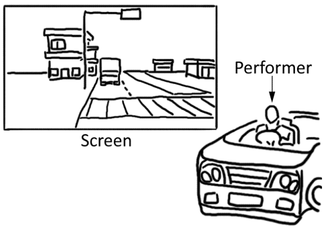

Figure 6: Performance carried out far from a screen

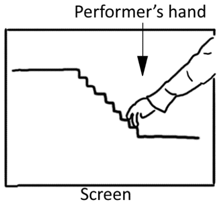

Figure 7: Performance using part of the body

formances using motion recognition techniques[1, 3]. Many existing systems, enhance stage performances with visual images, such as EffecTV[2]. In addition, many art performances use projectors[4]. These systems are designed to enhance the performance in general, and not to support the natural acting of the performer in performances, which is the purpose of our research.

Various system have been introdused to provide information to support professional activities. One example is a support system for motorbike races[5]. This system provides a variety of timely information on races, such as road conditions, accident information, and expected pit times. The Cyberguide[6] is a mobile guide system. This guide system uses context-awareness techniques to present effective information. In the medical field, various health monitoring systems have been introduced that provide information that helps patients stay healthy[7]. Although these studies confirmed the effectiveness of presenting appropriate information to users, to the best of our knowledge no research has been reported to date that considers the effectiveness of presenting information on interactive performances.

3. INTERACTIVE PERFORMANCES WITH PROJECTED IMAGES

The target of our research is to create a system for supporting interactive performances using projected images. To clarify the conventional problems, we categorize such performances and describe their characteristics. Most existing interactive performances are classified into two types. One is where the performer fits his/her actions to prescribed images such as a movie. The other is a performance where a system dynamically generates images based on the performer's action. In the former category especially, the performer must remember the image contents and concentrate on fitting his/her actions to the images on stage. It is therefore extremely difficult to do a performance that includes random elements because he/she cannot see the projected image while looking at the audiences. In this section, we categorize such performances from the viewpoint of the performer's situation and the required information. The difficulty in recognizing information on screen depends on these two factors.

Classification by performer's situation

- Performance facing the audience

  Figure 2 shows an example of a performance that combines a dancing performance and image effects. In this case, the performer cannot see the projected image without turning around.

- Performance facing a screen

  As shown in Figure 3, in some performances, the performer is in front of a screen and manipulates an object on the screen. In this case, it is difficult for the performer to see the entire image.

- Performance in parallel with a screen

  As shown in Figure 4, a performer is walking along the stage as an image scrolls in the background. In this case, he/she cannot see the entire image, especially the part behind him/her.

- Performance in contact with a screen

  In Figure 5, a performer is blowing bubbles from his mouth right next to the screen. In this case, it is difficult for the performer to see the entire image because the performer stays very close to the screen.

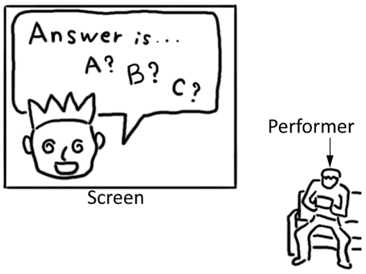

Figure 8: A performance based on information in image

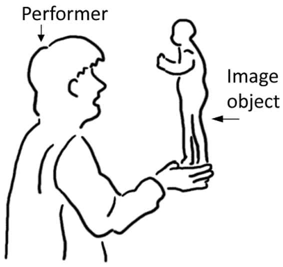

Figure 9: A performance based on a position

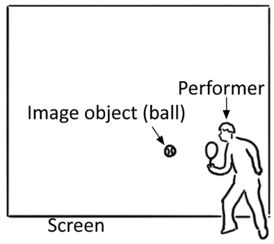

Figure 10: A performance based on a changing image

- Performance far from a screen

  Figure 6 depicts a scene from a comedy performance in which the performer is operating a real object that controls the projected image indirectly. When gazing at the real object, the performer cannot see the screen.

- Performance using part of the body

  In some performances, the performer uses just a hand, arm, or an other part of the body, as shown in Figure 7. He/She may not be able to see the screen depending on which part.

Classification by required information

- Performance based on information in image

  Figure 8 shows a comedy scene in which a performer is reading the text in the image. When the performer cannot see the screen, he/she has to memorize the dialog completely.

- Performance based on the position of performer/objects

  Figure 9 shows a performance in which a performer is touching an image object on the screen. When the performer cannot see the whole screen, he/she cannot accurately determine the distance between him/her and the object.

- Performance based on changing image

  In Figure 10, a performer is striking a ball in the image. In this kind of performance, the performer need to memorize the timing of his/her actions.

4. SYSTEM DESIGN

As described in Section 3, a performer cannot see the entire image on the screen in most situations on stage. This prevents performers from doing dynamically changing performances. Therefore, it is important for a performer to get various kinds of information to do a smooth/dynamic performance. In this paper, we propose an information presentation system for interactive performances. First, we clarify the characteristics of information presentation devices and the presenting content, and then describe our implementation of a prototype system.

4.1 Selection of presenting content

Various types of content can be presented as information such as images, sounds, and vibrations. Since the required information is expressed visually, it is difficult to present the information as sounds or vibrations. Accordingly, we chose images as the method to present content. We prepared the following types of content to support interactive performances.

- Performance-image method

  In this method, the system presents the same image as the projected image. It has high visibility and no delay. However, the performer cannot grasp the positional relationship between him/herself and the image object.

- Camera-image method

  This method presents real-time captured images from a camera in front of the stage. Since the image includes the projected image and the performer, he/she can understand the positional relationship between him/herself and the image object. On the other hand, there is a delay in displaying the image because of capture delay. Moreover, compared with the performance-image method, the quality of the image is not as good due to various factors such as camera resolution.

Other methods are also possible, for example, a system that presents future scenes to allow the performer to grasp the flow of the performance. However, because it is necessary to edit content to realize such a method, we employ the two methods just described that require no additional effort by the for content creators.

4.2 Selection of display device

It is important to choose the appropriate information presentation device to achieve a smooth performance. Considering the performance characteristics described in Section 3, the display device should have sufficient adaptability for various situations. We investigate the following devices and clarify their characteristics in Table 1.

- HMD

  With this device, the performer can recognize the image regardless of direction, position, or posture. However, the appearance of the current HMD is unnatural, and it may restrict the performer's actions.

- Monitor

  The performer may not always be able to see the monitor without changing direction. In addition, the installation cost is high if multiple displays are used at the same time.

Table 1: Characteristics of information display devices

	Volume of information	Reading accuracy	Installation cost	Freedom of action	Ease of installation	Appearance
HMD	○	△	○	○	○	×
Monitor	○	○	×	×	N/A	○
Projection on floor	○	○	×	△	N/A	△
Earphones	×	△	○	○	○	○

○: Good, △: Not bad, ×: Insufficient

- Projection on floor

  The presented image is projected from a high position, as in an arcade game[8]. Images can be displayed in any position on the floor. However, it requires a very large installation cost, and there are environmental restrictions.

- Earphone

  This is suitable for performances with a lot of action since the wearable device is sufficiently small. However, sound alone cannot deliver enough information to the performer. Therefore, it should be used with another method.

Accordingly, projection on the floor and earphones cannot be used with our system. In addition, a monitor cannot be watched continuously when a performer faces the screen. When necessary information changes in the performance, or two or more kinds of information are required, the HMD is effective. Therefore, we adopted the HMD as display device.

4.3 System structure

Figure 11 illustrates the structure of our system. It consists of a PC, a projector to present content to the audience, an information presentation device for the performer, an input device for the performer, and a camera. Content is projected on the screen. The performer acts based on the information from the presentation device. As an input device to control the presented content, a wireless button, camera-based picture processing, or wireless acceleration sensor could be used.

4.4 Prototype implementation

We implemented a prototype of the performer support system. Figure 12 shows a performer using our system. We used a Sony VGN-FE90S computer(CPU 1.83 GHz×2, RAM 1 GB), with a Windows XP operating system, a Shimadzu DataGlass2/A HMD, an I-O data USB-RGB (resolution 800×600 pixels, 60 Hz) external graphics adapter, and a Buffalo BWC-35H01 (resolution 320×240 pixels, 30 fps) camera. Image content used on the stage and presented for the performer was sent from the PC and displayed on the screen and on the HMD. As an input device, we used an Elecom M-D13UR wireless mouse(maximum length 10 m), as shown in Figure 12. We created several images for performances using Processing[9].

5. EVALUATION

We conducted three evaluations to investigate the effectiveness of the proposed system. In these evaluations, we clarified the characteristics and the effects of the system by changing the presented content and display devices. As the

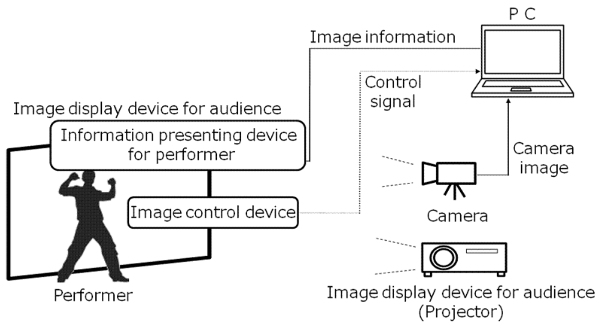

Figure 11: System structure

Figure 12: Photo of a performer using our system

global setting of the evaluation, the distance between the projector and the screen was 7 m. The projected image size was 2.7 m×2 m. The bottom of the image was 60 cm from the floor. We used a 17 inch monitor and set it in front of the stage. The camera was positioned near the projector.

5.1 Evaluation from performers

We implemented three games to evaluate the speed of performing action, the accuracy of a positional understanding, and the timing recognition accuracy. We evaluated the scores of these games by changing the information presentation devices: the HMD, monitor, and no support, with two types of content: performance image and camera image. The details of the games are as follow:

- Reading character game

  The purpose of this game is to evaluate the action accuracy and the recognition speed. Figure 13 shows a photo of a user playing this game. A letter of the

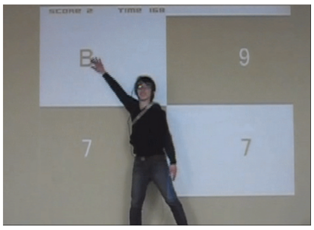

Figure 13: Reading character game

Figure 14: Ball catching game

Figure 15: Rhythm game

alphabet is randomly displayed at one of four areas on the screen, and numbers are displayed in the other three areas. The performer touches the area where the letter is displayed. One point is added to the score when the performer selects the correct area. The duration of one round of this game is 40 seconds.

- Ball catching game

  This game is used to evaluate the player's understanding of the object position. Figure 14 shows a photograph of a performer playing this game. A ball falls down from the top of the screen. The performer catches the ball by hand. One point is added to the score when the performer catches the ball at the correct position. One round of this game is 50 counts.

- Rhythm game

  The purpose of this game is to evaluate the timing recognition of changing images. Figure 15 shows a photo of a performer playing this game. A circle moves randomly from the center of the screen to one of the circles located in the four corners. The performer presses the button when the two circles overlap. One or two points is added to the score based on the accuracy. The duration of one round of the game is 50 counts.

Five college students played all three games with each combination of device and presenting content. They played them in random order considering the learning effects. We measured the differences in each evaluation result using ANOVA (significance level was 5%). In addition, we questioned players about the ease of playing the game with each presentation device.

Figure 16 shows the average score results for each game. In the rhythm game, the no support scores are clearly lower than the others. Accordingly, when timing recognition is required, a display device is necessary.

Figure 17 plot the results of the average score for each device. There is no significant difference between the two display devices. Consequently, the HMD and the monitor are equal in acting accuracy, understanding of position, and timing recognition.

In Figure 18, the results of the average points for both types of presenting content are shown. In the reading character game, the score of the performance-image method was higher than that of the camera-image method. This is because the performance-image method is more visible than the camera-image method. Accordingly, it is more effective for recognizing text-based information. In the ball catching game, the score of the camera-image method was higher

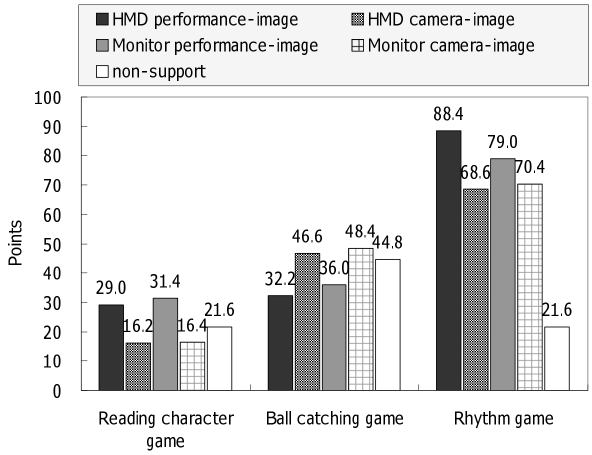

Figure 16: Game scores

than that of the performance-image method. This is because the camera-image method enables the performer to watch the relatioship between him/herself and a ball object. Accordingly, the camera-image method is effective when the user needs to know the relationship between his/her own position and the object. In the rhythm game, the score of the performance-image method was higher. This is because the camera-image method has a delay in displaying images. Accordingly, the performance-image method is more effective when the user needs to know the timing of changing images.

Figure 19 shows the results of the questionnaire about the ease of playing each device. There were no significant differences in any of the games.

5.2 Evaluation from audience

In this evaluation, a performer carried out three performances in front of 16 test subjects (all college students), who evaluated the naturalness of the performance when the performer viewed the information via a display device. The combination of presentation device and presenting content were the same as in the evaluation described in Section 5.1. All evaluations were done using a questionnaire (1: bad – 5: good). The details of each performance are as follows:

- Moving picture performance

  The purpose of showing this performance was to evaluate the naturalness of the situation when the performer is facing the audience. Figure 20 shows a photo of this performance. The performer reads the direction of the arrow displayed randomly in four directions, and

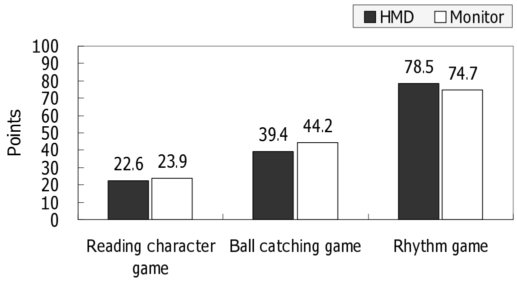

Figure 17: Game scores for each display device

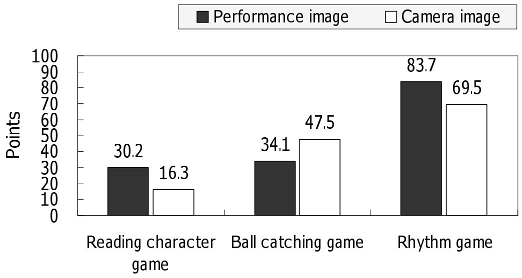

Figure 18: Game scores for both content presentation methods

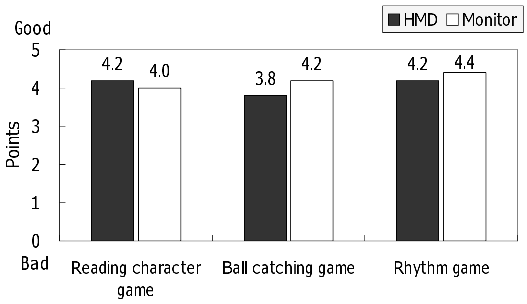

Figure 19: Ease of playing scores

mimes the motion of moving the picture in the direction of the arrow.

- Bowling performance

  The purpose of showing this performance was to evaluate the naturalness of the situation when the performer is far from the screen and using real a object. Figure 21 shows a photo of this performance. A performer rolls a ball towards the screen from approximately three meters away. The performer also operates a button, and the pins in the image fall down. In this performance, the screen was small (1.2 m×1.6 m).

- Soap bubble performance

  The purpose of showing this performance was to evaluate the naturalness of the situation when the performer actually touches the screen. Figure 22 shows a photo of this performance. A circle randomly appears on the screen. The performer approaches it, and pretends to blow on it, which produces more bubbles.

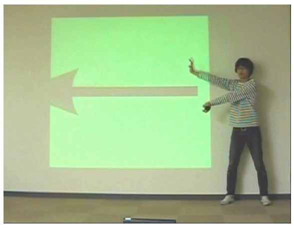

Figure 20: Moving picture performance

Figure 21: Bowling performance

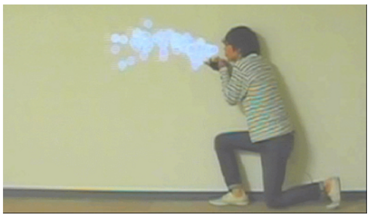

Figure 22: Soap bubble performance

Figure 23 plots the results of the average score for each device. The moving picture and bowling performances, showed no significant differences. Therefore, in these performances, a performer can see the presented image naturally using both a HMD and a monitor. On the other hand, in the soap bubble performance, the HMD score was higher than that of the monitor. This is because the motion of looking at the monitor is conspicuous when the performer is in close contact with the screen. Accordingly, HMD is more effective in performances involving contact with a screen.

Figure 24 plots the results of the average score for each presenting image. There were no differences in all of the performances.

Figure 25 plots the results of the average score for the naturalness of the appearance of wearable device. The appearance of the HMD was fairly good, but some people were uncomfortable with the way it looked. The miniaturization of the HMD will solve this problem. The appearance of the wireless mouse was rated high. Therefore, a wireless mouse can be an effective tool for stage performances.

5.3 Evaluation of physical effects

We implemented a game to evaluate the physical effects of wearable devices in performances. Figure 26 shows a photo of an user playing this game. A circle appears randomly on the left or right side of the screen. The performer hits the circle based on information from the HMD. One round of the game consists of 20 times. In addition, two motions

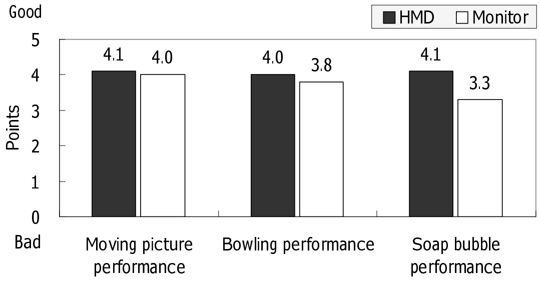

Figure 23: Score of naturalness for each device

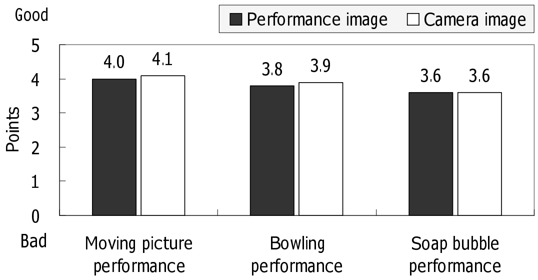

Figure 24: Score of naturalness for displayed content

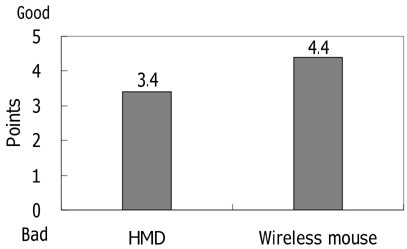

Figure 25: Score of naturalness in appearance

were added to the game to evaluate the effects of vigorous movements. Figure 27 shows an additional motion of a side step, and Figure 28 shows an other turn motion. The performer must do these motions before hitting the circle. Five college students played the game with no additional motions and with the two additional motions. The experimental environment was similar to the case described in Section 5.1. We used the Shimadzu DataGlass3/A as the HMD.

Figure 29 are the average score results, and it is clear that wearing the HMD has a negative effect on the motion. With no additional motion, the HMD did not have any effect on the performance at all. When the additional motions were added, the evaluation results declined compared to that of no additional motion. However, this result does not indicate that using on HMD is not suitable for performances with vigorous activity, and we can use wearable devices in most types of performances.

6. ACTUAL USE IN AN EVENT

We used the prototype on stage at the Kobe Luminarie [10] on December 13th and 14th, 2008. The Kobe Luminarie

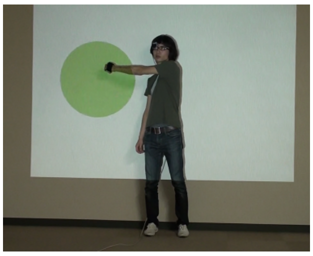

Figure 26: The motion of hit a circle

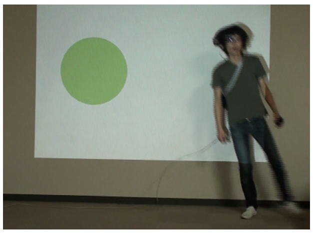

Figure 27: Additional movement of side steps

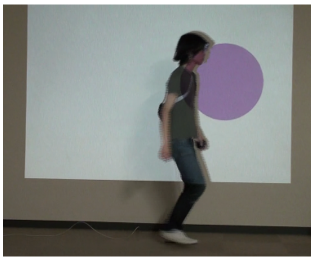

Figure 28: Additional movement of turn

has been held annually since December 1995 to commemorate the victims of the Hanshin-Awaji Earth quake and has been a symbol of reconstruction. In this event, we used the performance-image method. We showed the following three short performances:

- Title Call

  Title Call is a performance in which a message is told to the audience. Figure 30 shows a photo of this performance. The performer moves a message with push/pull motions.

- Bowling

  Bowling is a performance that collaborates images with a real object. A performer has a real ball and rolls the ball towards the screen from several meters away, as shown in Figure 31, and the pins on the image fall down.

- Interactive Bubbles

  Figure 32 shows an image of this performance. A performer generates many circles by the action of blowing on a point on the screen, and these circles make a text message.

In Title Call, the performer was able to act based on the HMD image. However, since there was no feedback from

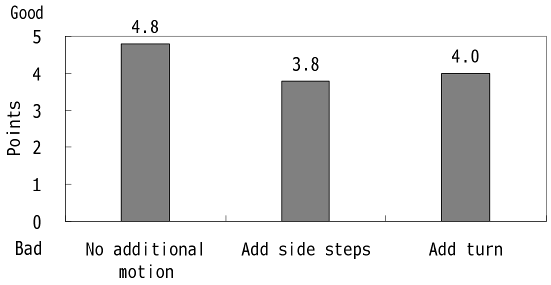

Figure 29: Effect of HMD on performance movement

a button operation, the performer was not able to confirm if the operation was accepted by the system. Therefore, we have to develop an effective feedback method in future systems. In Bowling, our system was effectively used when the performer was moving around the stage. In Interactive Bubbles, the performer was able to act without unnaturally glancing at the information to adjust his/her position.

From these actual uses, we found that we need more portable devices that have wireless communication functions. Moreover, the current prototype is sufficiently effective in interactive performances, but it is possible to construct a much more powerful system by carefully considering the presenting content. For example, if the presenting information includes the feedback of the button operation, it reduces the number of operational errors in performances.

7. CONCLUSION

In this paper, we described a performer support system for interactive performances using projected images. We evaluated several information display devices and presenting content to investigate the effects of these factors on the quality of the performances. From the evaluation, we confirmed that our method is effective for making performances more accurate and more natural.

In the future, we will work on developing more useful presentation information, for example, by emphasizing important objects, and adding the next scene. We will also consider how to support a performance given by multiple persons. We need to compare differences between beginners and skilled performers. In addition, we will work on providing various functions and development environments to make interactive performances using our method.

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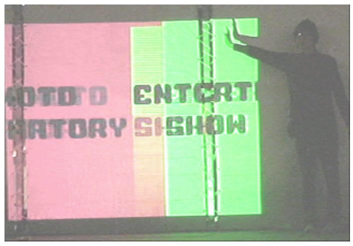

Figure 30: Action of moving a picture

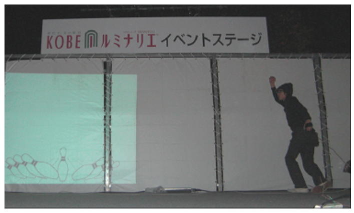

Figure 31: Appearance of breaking pins

Figure 32: Action of blowing bubbles