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EVALUATION ON PERFORMER SUPPORT METHODS FOR INTERACTIVE PERFORMANCES USING PROJECTOR

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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.

Keywords: interactive performance, projector, media art
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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

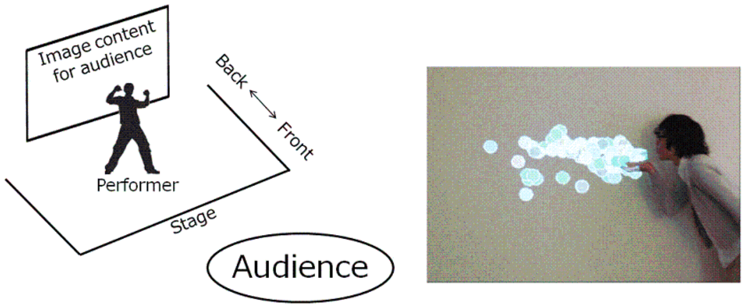

Fig. 1. A performance with projected images

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.

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 performances for entertainment, many performances are interactive and utilize computer technologies, such as dance performances using motion recognition techniques[1, 3]. As an example of interaction between image contents and human's activity, VIDEOPLACE[4] combines a participant's live video image with a computer graphic world. In this system, the participant can touch a graphic ball or swim in graphic sea. In addition, many table-top systems have interactivity between human's hands and presented images, such as Media Tables[5]. This system provides the interaction between tangible objects and projected images. However, these systems do not consider performance to audience.

Many existing systems enhance the stage performance with visual images such as EffecTV[2]. This system applys real-time effects to camera images, and it achieves highly interactive system by capturing people movements like dancing. P. Hämäläinen developed interactive game system using artificial reality[6]. In this system, the player fights against characters in image by Kung-Fu. However, our approach does not target at artificial reality. M. Reynolds proposes musical stage environment[7]. This system reflects juggling clubs movement in sound. In this research, interaction between object in image and performer's action is not considered.

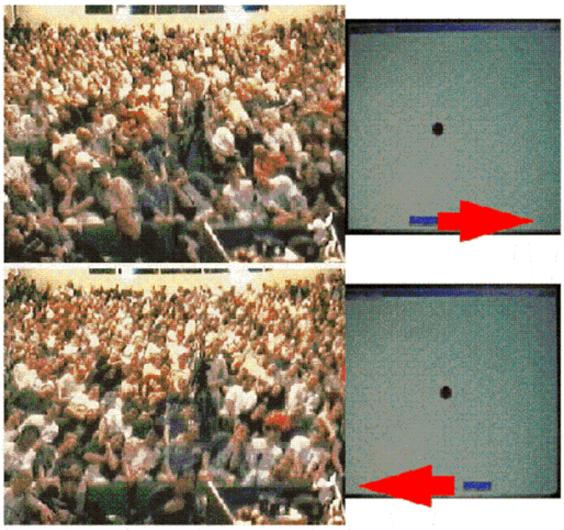

Fig. 2. A large audience leans left and right to control a ball in image[14].

Many art performances use projectors[8, 9, 10]. Messa di Voce is a an audio-visual performance in which the speech, shouts and songs produced by two vocalists are radically augmented in real-time by custom interactive visualization software. These systems are designed not to support the performer in performances, which is the purpose of our research.

Various systems have been introduced to provide information to support professional activities. One example is a support system for motorbike races[11]. This system provides a variety of timely information on races, such as road conditions, accident information, and expected pit times. The Cyberguide[12] is a mobile guide system that 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[13]. Although these studies confirmed the effectiveness of presenting appropriate information to users, to the best of our knowledge, no research has been reported, which 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 problems in the conventional performances, we categorize the performances and clarify their characteristics. Most existing interactive performances are that the performer fits his/her actions to prescribed images such as a movie. In these performance, the performer must remember the flow of image contents and concentrate on fitting his/her actions to the images on stage. As a different type performance, there are performances that combine audience's action and presented images[14]. Figure 2 shows an example of performance that the audience can handle a ball in image by leaning them left and right. In addition, there is a type of performance that a system dynamically generates images based on the performer's action. In such performances, since the generated effect or the constructed story at every show, the performer cannot memorize the image contents beforehand. Therefore, it is extremely difficult to do a performance without seeing 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.

Classification by performer's situation

- Performance facing the audience

  Figure 3 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 4, 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 5, 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 6, 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.

- Performance far from a screen

  Figure 7 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 8. He/She may not be able to see the screen depending on which part.

Note that the situations in Figure 4,5,8 can be seen in the professional performance of "LIVE「POTSUNEN」& LIVE POTSUNEN 2006「◯ ~ maru ~」" (PONY CANYON, DVD, 2007) by Kentaro Kobayashi. Figure 7 can be seen in the TV show of "The God of Entertainment" (Nippon Television Network Corporation).

Classification by required information

- Performance based on information in image

Fig. 3. Performance facing the audience

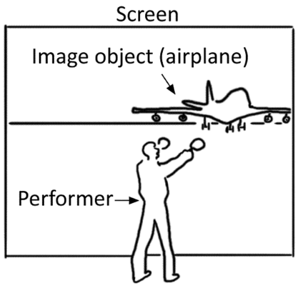

Fig. 4. Performance facing a screen

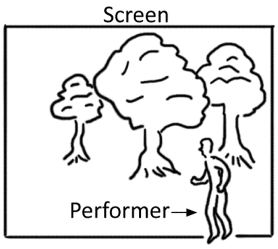

Fig. 5. Performance in parallel with a screen

Fig. 6. Performance in contact with a screen

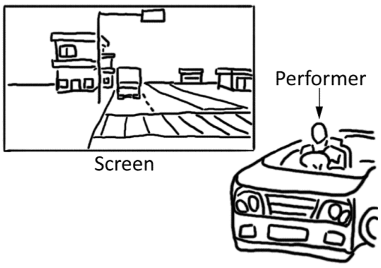

Fig. 7. Performance carried out far from a screen

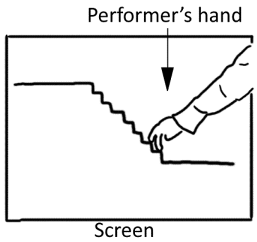

Fig. 8. Performance using part of the body

Figure 9 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 10 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 11, 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.

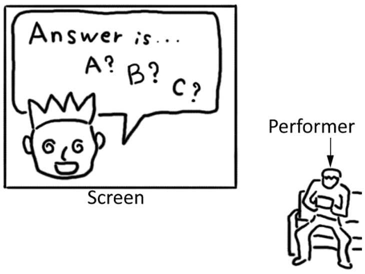

Fig. 9. A performance based on information in image

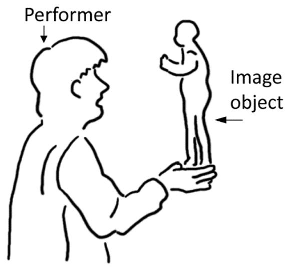

Fig. 10. A performance based on a position

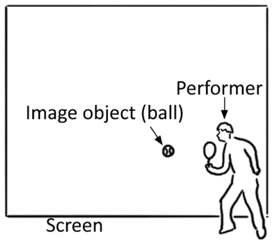

Fig. 11. A performance based on a changing image

Note that the situations in Figure 9 can be seen in the TV show of "The God of Entertainment" (Nippon Television Network Corporation). Figure 10 can be seen in the professional performance of "Nakamaru kun no tanosii jikan" (2008) by Yuichi Nakamaru. Figure 11 can be seen in the professional performance of "LIVE「POTSUNEN」 & LIVE POTSUNEN 2006 「○ ~ maru ~ 」" (PONY CANYON, DVD, 2007) by Kentaro Kobayashi.

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.

Fig. 12. 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

- 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 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 12.

- HMD

  With this device, the performer can recognize the image regardless of direction, position, or posture. Since, a stage environment does not influence on wearable devices, HMD can be used on any environmental conditions. 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 casting his/her eyes to the monitor. If the stage does not have enough space for setting the monitors, it is difficult to set monitors at appropriate positions. In addition, the installation cost is high if multiple displays are used at the same time.

- Projection on floor

  Image can be projected from a high position, as an arcade game[15]. Images can be displayed in any position on the floor. However, it requires a very large installation cost, and there are environmental restrictions. In addition, it is difficult to hide the projected images from the audience.

- Earphone

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

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, HMD is effective. Therefore, we employ HMD as display device.

4.3 System structure

Figure 13 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 14 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 14. We created several images for performances using Processing[16].

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 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

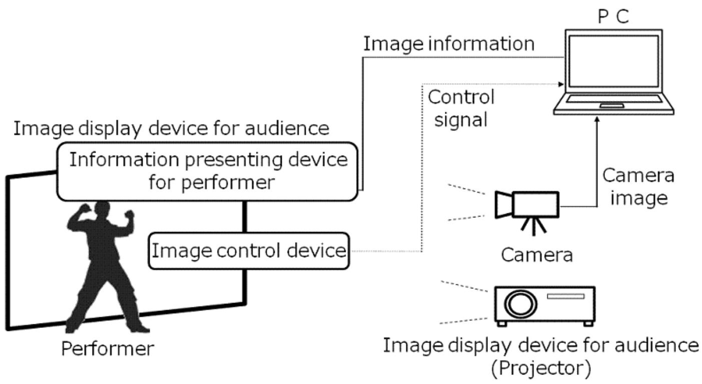

Fig. 13. System structure

Fig. 14. Photo of a performer using our system

The purpose of this game is to evaluate the action accuracy and the recognition speed. Figure 15 shows a photo of a user playing this game. A letter of the 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 16 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 17 shows a photo of a performer playing this game. A circle moves randomly

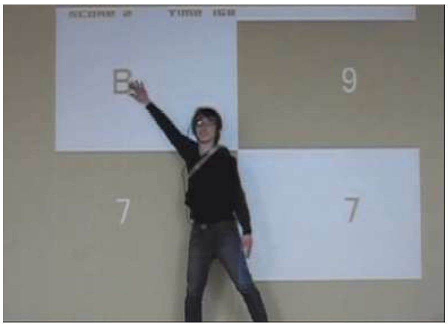

Fig. 15. Reading character game

Fig. 16. Ball catching game

Fig. 17. Rhythm game

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 devices and presenting contents. 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 asked players two questionnaire. One is the ease of playing the game with each presentation device. The other is the visibility with each combination of presented content and display devices.

Figure 18 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 19 plots 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 20, 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 than that of the performance-image method. This is because the camera-image method enables the performer to watch the relationship 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 21 shows the results of the questionnaire about the ease of playing each device. There were no significant differences in any of the games. Figure 22 shows the results of the questionnaire about the visibility with each combination of presented content and display devices. There is no significant difference between the two display devices. On the other hand, presenting content has effect on the visibility. 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 is more bright and clear than the camera-image method. This is because the camera-image method enables the performer to watch the relationship between him/herself and a ball object. In the ball catching game, the score of the camera-image method was higher than that of the performance-image method. These is the same result of the game score.

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 23 shows a photo of this performance. The performer reads the direction of the arrow displayed randomly in four directions, and 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 24 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$\times$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 25 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.

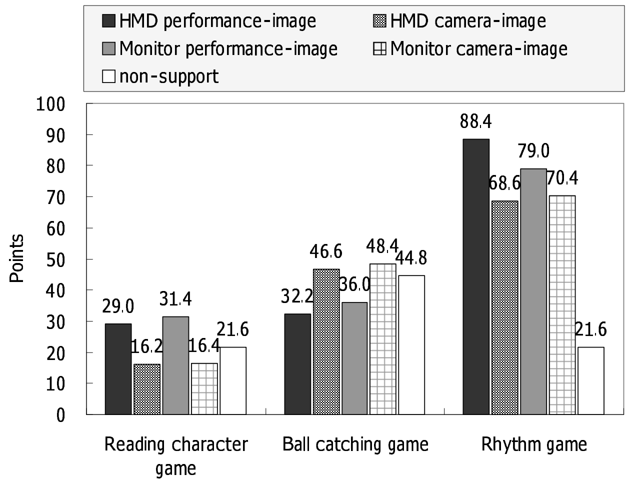

Fig. 18. Game scores

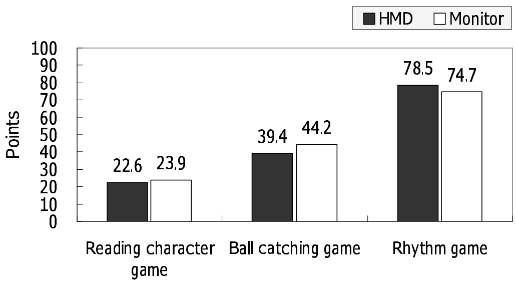

Fig. 19. Game scores for each display device

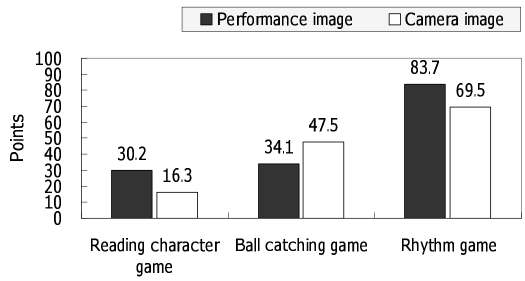

Fig. 20. Game scores for both content presentation methods

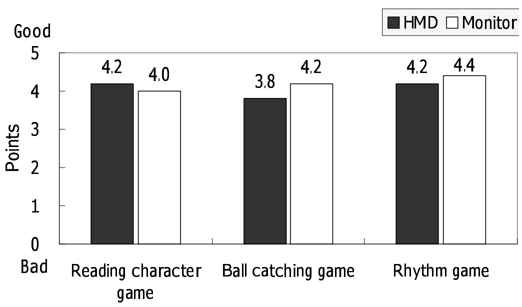

Fig. 21. Ease of playing scores

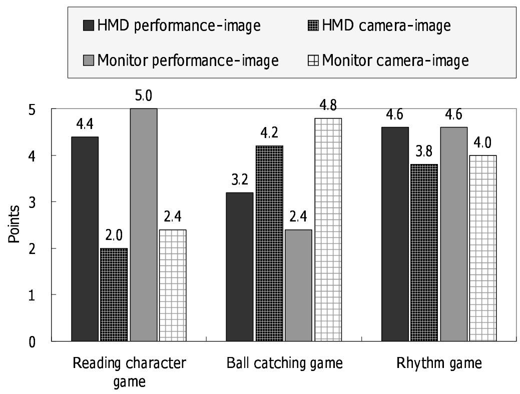

Fig. 22. Visibility scores

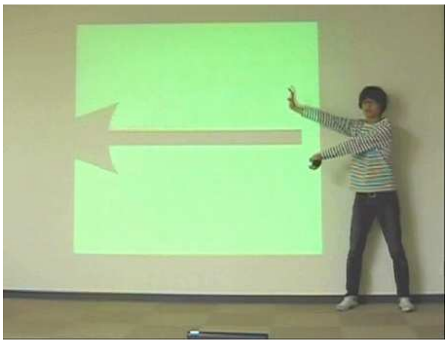

Fig. 23. Moving picture performance

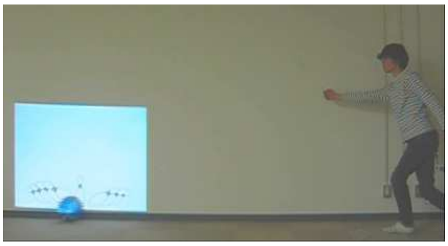

Fig. 24. Bowling performance

Fig. 25. Soap bubble performance

Figure 27 plots the results of the average score for each performance. Figure 27 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 28 plots the results of the average score for each presenting image. There were no differences in all of the performances.

Figure 29 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

In this evaluation, we evaluate the physical effects of wearable devices and connection cable between HMD and PC. The experimental environment was similar to the case described in Section 5.1. We used Shimadzu DataGlass3/A as HMD. All evaluations were done using a questionnaire (1: bad – 5: good).

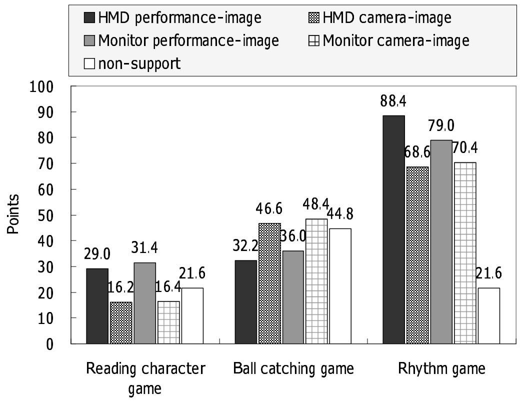

Fig. 26. Score of naturalness

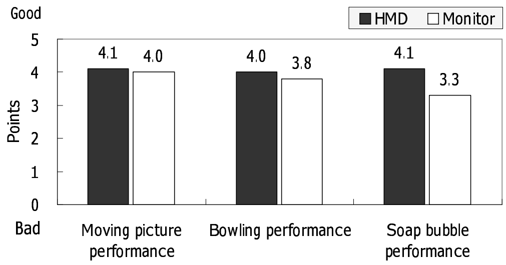

Fig. 27. Score of naturalness for each device

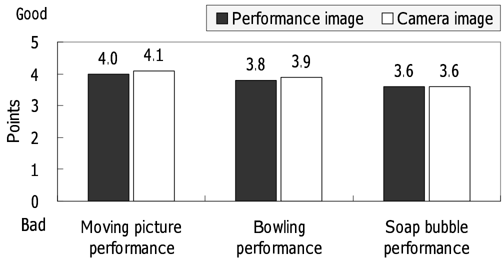

Fig. 28. Score of naturalness for displayed content

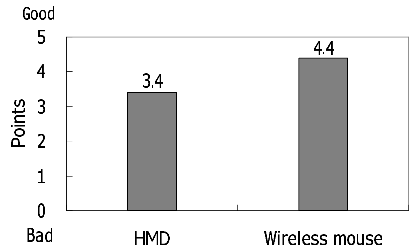

Fig. 29. Score of naturalness in appearance

5.3.1 Evaluation of physical effects from performer

We implemented a game to evaluate the physical effects of wearable devices and connection cable between HMD and PC in performances. Figure 30 shows a snapshot of an user playing the game. In the game, a circle appears randomly on the left or right side of the screen, and the performer hits the circle based on information on the HMD. One round of the game consists of 20 times of hitting. In addition, two motions were added to the game to evaluate the effects of vigorous movements. Figure 31 shows an additional motion of a side step, and Figure 32 shows another turn motion. The performer must do these motions before hitting the circle. Five college students played the game with no additional motion and with the two additional motions.

Figure 33 shows the average score of the effect of the connection cable, and it is clear that the cable has a negative effect on the motion. With no additional motion, the connection cable 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. This is because the cable entwined for the performer's leg. However, this problem can disappear using Wireless HMD.

Figure 34 shows the average score of the effect of HMD, and it can be read that wearing the HMD has a negative effect on the motion. With no additional motion, the HMD did

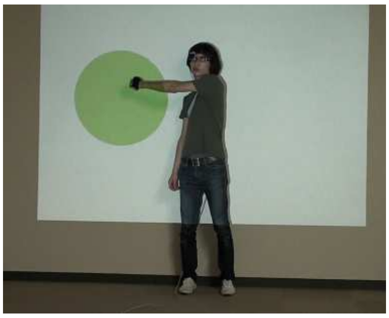

Fig. 30. The motion of hit a circle

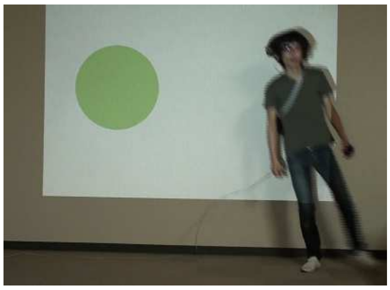

Fig. 31. Additional movement of side steps

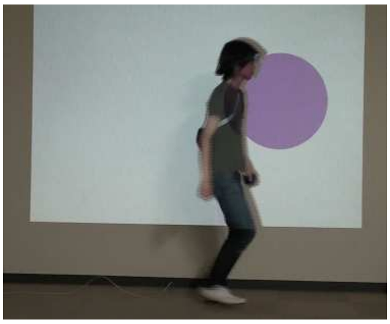

Fig. 32. Additional movement of turn

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, the effect of HMD is smaller than the effect of the connection cable. These score is near four points. Therefore, 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.

5.3.2 Evaluation of physical effects from audience

In this evaluation, a performer carried out three performances and two games in front of 10 test subjects (all college students), who evaluated the influence of connection cable from the viewpoint of the performance quality. Three performances are the same as those described in Section 5.2. Two games are the same as the game described in Section 5.3.1.

Figure 35 shows the average score. In the bowling performance and two games, it is clear that connection cable has a negative effect on the performance quality. This is because the cable entwined for the performer's leg. However, this problem will disappear by using Wireless HMD.

6 Actual use in events

Kobe Luminarie 2008

We used the prototype on stage at *the Kobe Luminarie* [17] on December 13th and 14th, 2008. The number of audience were about 150. *The Kobe Luminarie* has been held annually since December 1995 to commemorate the victims of the Hanshin-Awaji Earth quake and has

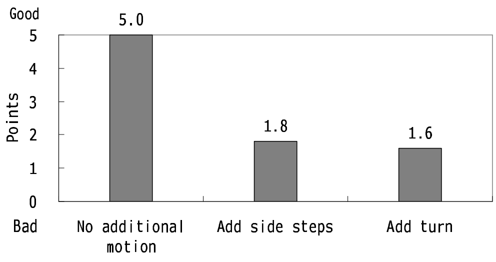

Fig. 33. Effect of connection cable on performance movement

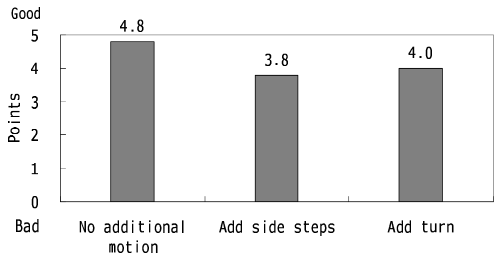

Fig. 34. Effect of HMD on performance movement

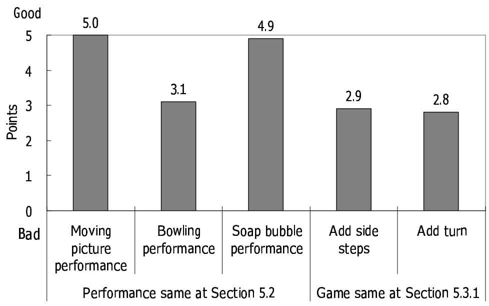

Fig. 35. Effect of connection cable on performance quality

been a symbol of reconstruction. We showed the following three short performances:

- Title Call

  Title Call is a performance in which messages are presented to the audience. Figure 36 shows a snapshot of this performance. The performer moves a message with push/pull motions.

- Bowling

  Bowling is a performance that is a collaboration between images and a real object as shown in Figure 37. A performer rolls a real ball towards the screen that shows pins of bowling, from several meters away, as shown in Figure 38. When the ball reaches the screen, the pins on the image fall down.

- Interactive Bubbles

  Figure 39 shows a snapshot of this performance. A performer generates many bubbles by the action of blowing on a point on the screen, and these bubbles consist a text message when the performer hits the screen.

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

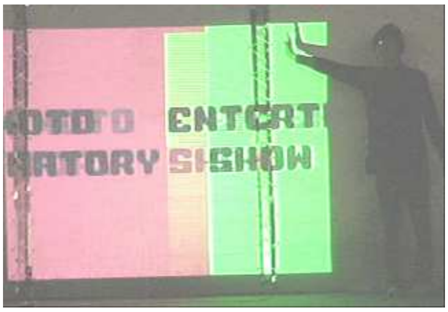

Fig. 36. Action of moving a picture

Fig. 37. Action of using a ball

Fig. 38. Appearance of breaking pins

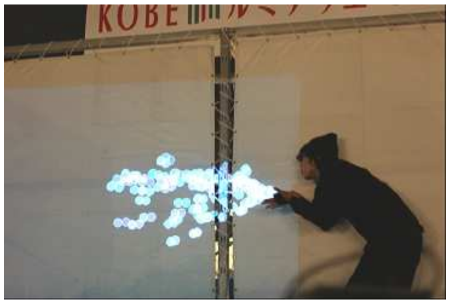

Fig. 39. Action of blowing bubbles

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. We gain some impressions and opinions from audience as the followings:

- The performer act with image contents naturally.
- We are not concerned about HMD in the stage because the stage lighting is dim.

Marriage ceremony

We used the prototype on stage at a marriage ceremony on June 27th, 2009. The audiences were about 100 people. We presented the performance to show congratulant messages. Figure 40 shows a snapshot of an appearing message from balls. In this performance, the performer was able to recognize a timing of appearing/disappearing balls based on the HMD image.

Symposium

We used the prototype on stage at Our laboratory 5th Anniversary Symposium named Wearable/Ubiquitous Computing Symposium on October 30th, 2009. About 100 people watched our performance of looking back on five years. Figure 41 shows a snapshot of a scene that balls are transformed into the picture of one of the authors. The performer was able to act based on the HMD image even if the large screen.

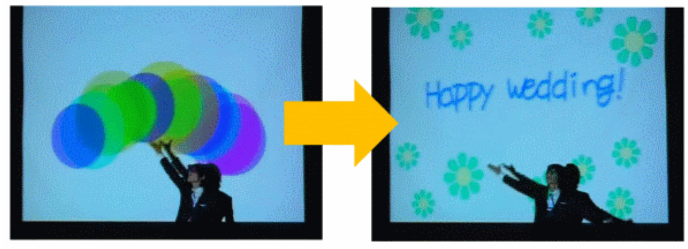

Fig. 40. Message appears from balls

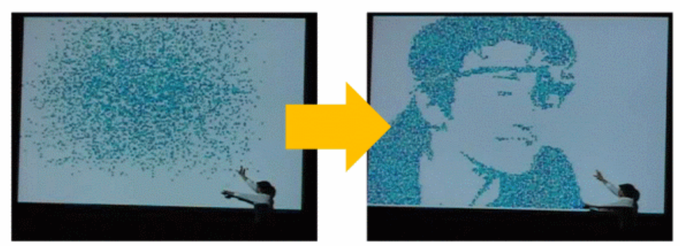

Fig. 41. Making face picture by balls

Kobe Luminarie 2009

We used the prototype on stage at *the Kobe Luminarie* on December 12th, 2009. About 150 people watched the following two short performances:

- Punch!

  Punch is a performance that the performer punches image objects. Figure 42 shows an action of punching. In this performance, the performer acts avoiding flying objects from behind as shown in Figure 43.

- Rainy day

  Rainy day is a performance that collaborates images with a real object. A performer has a real umbrella and walks in the rainy scene, as shown in Figure 44, and raindrops bounce from the umbrella. In this performance, there is a scene that the performer acts facing the audience as shown in Figure 45.

In Punch!, the performer was able to avoid flying objects from behind based on the HMD image. In Rainy day, the performer was able to act naturally facing the audience.

From these actual uses, we found that we need more portable devices that have wireless communication functions. Moreover, although the current prototype is sufficiently effective in interactive performances, 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

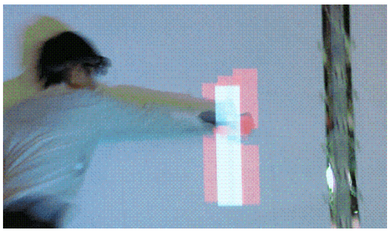

Fig. 42. The action of punching an object

Fig. 43. The action of avoiding an object from backward

Fig. 44. The action of using an umbrella

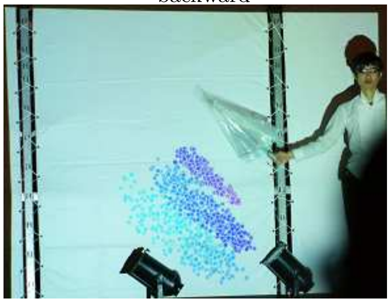

Fig. 45. The action toward audiences

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.

Acknowledgments

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References

1. M. Fujimoto, N. Fujita, Y. Takegawa, T. Terada and M. Tsukamoto: Musical B-boying: A Wearable Musical Instrument by Dancing, Proc. of the International Conference on Entertainment Computing (ICEC 2008), pp. 155-160(2008).
2. K. Fukuchi, S. Mertens and E. Tannenbaum: EffecTV: a real-time software video effect processor for entertainment, Proc. of the International Conference on Entertainment Computing (ICEC 2004), pp. 602-605(2004).
3. R. Aylward and J. Paradiso: Sensemble: A Wireless, Compact, Multi-User Sensor System for Interactive Dance, Proc. of the International Conference on New Interface for Musical Expression

(NIME06), pp. 134-139(2006).
4. MW. Krueger, T. Gionfriddo and K. Hinrichsen: VIDEOPLACE: an artificial reality, ACM SIGCHI Bulletin, Vol. 16, Issue 4, pp. 35-40, 1985.
5. M. Alexandra: Media Tables: An extensible method for developing multi-user media interaction platforms for shared spaces, Massachusetts Institute of Technology, 2005.
6. P. Hämäläinen, T. Ilmonen, J. Höysniemi, M. Lindholm, A. Nykänen: Martial arts in artificial reality, Proc. of the Conference on Human Factors in Computing Systems (CHI 2005), pp. 781-790, 2005.
7. M. Reynolds, B. Schoner, J. Richards, K. Dobson, N. Gershenfeld: An immersive, multi-user, musical stage environment, Proc. of the ACM Siggraph(SIGGRAPH01), pp. 553-560, 2001.
8. S. Snibbe and H. Raffle: Social immersive media: pursuing best practices for multi-user interactive camera/projector exhibits, Proc. of the Conference on Human Factors in Computing Systems (CHI 2009), pp. 1447-1456 (2009).
9. messa di voce `http://www.tmema.org/messa/messa.html.`
10. Projection on building, NuFormer Digital Media `http://www.projectiononbuildings.com/en.`
11. T. Terada, M. Miyamae, Y. Kishino, T. Fukuda, and M Tsukamoto: An Event-Driven Wearable Systems for Supporting Pit-Crew and Audiences on Motorbike Races, iiWAS2008 Special issue in Journal of Mobile Multimedia (JMM), Vol. 5, No. 2, pp. 140-157 (2009).
12. G. Abowd, C. Atkeson, J. Hong, S. Long, R. Kooper and M. Pinkerton: Cyberguide: A mobile context-aware tour guide, Wireless Networks, Vol. 3, No. 5, pp. 421-433(1996).
13. A. Durresi, M. Durresi, A. Merkoci, L. Barolli: Networked Biomedical System for Ubiquitous Health Monitoring, Mobile Information Systems, Vol. 4, No. 3, pp. 211-218 (2008).
14. D. Maynes-Aminzade, R. Pausch, S. Seitz:Multimodal Techniques for interactive audience participation, Proc. of the International Conference on Interfaces(ICMI 2002), pp. 15-20, 2002.
15. UFO Stomper, `http://www.highwaygames.com/products/view.php?id=3432.`
16. Processing, `http://processing.org/.`
17. Kobe luminarie, `http://apike.ca/japan_kobe_luminarie.html.`