

科学コミュニケーションのための高精細立体ドーム環境の有効性評価 Evaluation of Super High Definition Stereo Dome Environment for Science Communication

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Abstract: In National Museum of Emerging Science and Innovation, the design of stereo dome theater was started in 2007 to visualize the space simulation that was the results of “4D digital universe project” conducted in National Astronomical Observatory. Based on discussions, a basic specification of super high definition stereo dome environment that uses the advanced 4K projectors was decided, and it was completed in December 2008. Science education program "Birthday" was produced by using the scene created by the space simulator, and it is currently being screened. It is important to evaluate and verify the sensations of three-dimension, high resolution image and immersion that were felt in the super high definition stereo dome environment to apply this system to the activities of the science education and the scientific communication. The evaluation result can be used as a guideline of producing effective science education program.

Keywords: Super High Definition Image, 4K Stereo, Dome Screen, Planetarium, Science Communication, Science Education.

1. Introduction

Recently, projecting digital 3D stereo images has been one of the theater trends. Moreover, image projection systems for the dome environment that utilize the features of immersion and wide viewing angle have been developed [Lantz02, Yu05]. On the other hand, in National Museum of Emerging Science and Innovation, it is one of the important themes to promote the activities of science education and science communication. Therefore, the development of the advanced dome theatre that integrates the technologies of the digital 3D stereo image and the dome environment would be effective.

In January 2009, the dome theater in National Museum of Emerging Science and Innovation was renewed to screen the result of "4D digital universe project" conducted in National Astronomical Observatory. In this theater, super high definition stereo dome system using stereo 4K image that was a technological trend of the theater in recent years was installed, and it was named “Atmos” (see Figure 1 and Figure 2). We aims at creating high realistic images and promoting science communication by using the high presence dome display environment.

Therefore, the purpose of this research is to obtain a guideline to produce the science education program and to promote the science communication by using the super high definition stereo dome environment. The evaluation experiment was conducted by using the scenes selected from the currently showing program, and the policy and directionality for the use was summarized based on the experimental results.

Before our research, four dimensional visualization system "4D digital universe theater" was developed in National Astronomical Observatory to visualize the universe and the astronomical phenomenon in the four dimensional space that consists of three dimensional space and one dimensional time [Kokubo03]. In this system, space and time could be expressed in various scales of the space and

time as an object of astronomy research. In addition to these functions, our study aims at visualizing the evolution of the space structure and experiencing the actual observation data using the most advanced graphics computer and super high definition stereo dome environment.



Figure 1: Appearance of Miraikan dome theater.



Figure 2: Projected image in Miraikan dome theatre
(c)4D2U Project, NAOJ

2. 4K super high definition stereo dome system

In the development of image projection system that promotes the science communication, consideration of performance, stability, and maintenance of the system are important. In this study, before the development of new dome system, 4K projector has been tested to project the super high definition image onto the 750-inch large screen in several science events. Then, it was verified that the effect of high presence sensation in the super high definition image could be experienced from the images projected onto the large screen. Therefore, we could expect the effect of 4K super high definition image, even if it was used in the dome environment because it has almost same scale of the screen size.

As for the projection system to project super high definition stereo image, four Sony 4KSXRD projectors (two sets of stereo 4K projectors) were installed because they have high quality of resolution and high color reproducibility. Moreover, super wide angle fish-eye lenses were attached to the 4K projectors, so that the dome screen was divided into two regions. In this basic specification of the projection system, since a synthetic area of blending image was decreased, the efficiency of maintenance would be improved.

As for the method of generating stereo image, Infitec 3D filters and glasses that use the wavelength division multiplex method was used as shown in Figure 3. The advantage of this method is projecting stereo image onto the dome screen without adding any special painting onto the screen surface. The stereo image can be projected by setting up the Infitec filters in the optics system of the 4K projectors. Figure 4 shows the system construction of the super high definition stereo dome system that was used in the experiment and Table 1 shows the specification of this system.



Figure 3: Audiences wearing Infitec 3D glasses

Table 1: Specification of super high definition stereo dome environment.

Dome diameter	15.24 m
Dome inclination angle	23.5 degrees
Sound	7.1 ch surround
Number of seats	112 seats
Projector	Sony 4KSXRD x 4
Stereo vision method	Wavelength division multiplex method

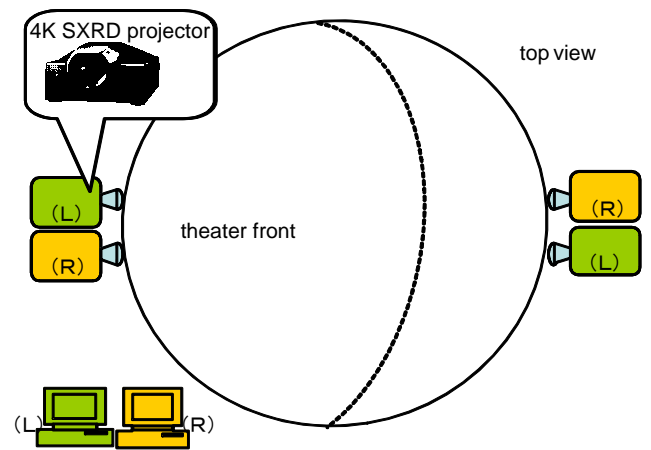


Figure 4: System construction of super high definition stereo dome system.

3. Evaluation experiment

3.1. Program contents

In order to investigate the effect of the super high definition dome environment, evaluation experiment was conducted using the 3D image program “BIRTHDAY -What Links the Universe and Me-”. This program explains the simple and grand theme, “How the universe is constructed?” and “What kind of relation exists between the universe and our life?” We can learn from the program that when we travel farther and farther into the universe through Sun, solar system and Milky Way Galaxy, we find ourselves at the place where all started.

3.2. Experiment method

In this experiment, two scenes with different features were selected from the above-mentioned program. We asked 13 subjects to see the program contents and to answer the following questionnaires about the sensations of three-dimension, immersion, and high resolution, etc. for each scene using a five grade system from -2 to 2.

Evaluation scene:

- space simulation scene (point based image)
- Mars panorama scene (polygon based image)

Psychological evaluation items for super high definition stereo image:

- high presence sensation
- three-dimensional sensation for near object
- three-dimensional sensation for infinite distant object
- continuous natural distance sensation from near view to distant view
- immersive sensation
- high resolution sensation

Figure 5 and Figure 6 show the screen shots of the evaluation scenes.

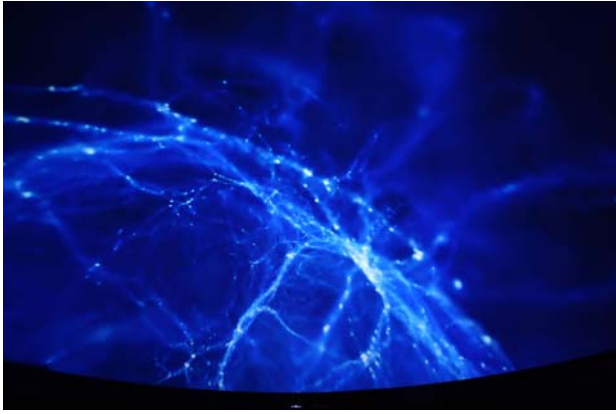


Figure 5: Space simulation scene (the Formation of Spiral Galaxy)
(c)4D2U Project, NAOJ

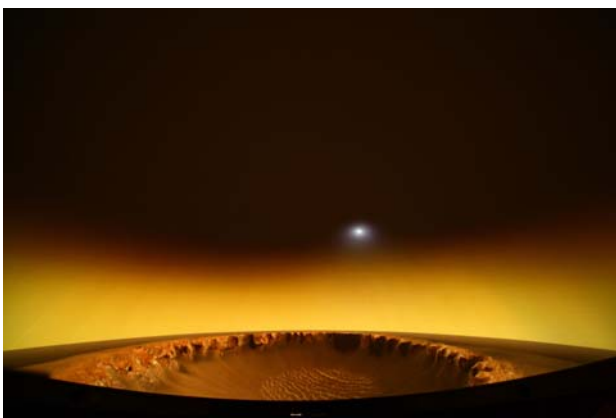


Figure 6 : Mars panorama scene.

3.3. Experiment result

The Figure 7 and Figure 8 show the results of this experiment. In these graphs, average values and standard deviations of the evaluation values for each scene are shown. From these results, we can see that the subjects felt the high presence sensation for each scene. Average values of the evaluations for (i) high presence sensation were 1.46 for space simulation scene, and 1.23 for Mars panorama scene. It is considered that this high presence sensation was caused by the overall effect of three dimensional sensation, high resolution sensation and immersive sensation.

As for the individual question, evaluations for (ii) three-dimensional sensation for near object and (v) immersive sensation were very high. The result of the evaluation for question item (ii) shows the effect of three-dimensional stereo image displayed in the dome environment. The result of the evaluation for question (v) verified the characteristic of the dome environment.

In the question items concerning to the three-dimensional sensation, evaluations for (iii) infinite distant object and (iv) continuous natural distance sensation were not so high (1.0 - 1.3). These results are considered to be caused by the structure of the dome screen in which the distance to the screen is fixed.

The evaluation for (vi) high resolution sensation (+1.00-+1.15) was lower than the evaluations for three-dimensional

sensation and (v) immersive sensation. The quality of the textures (grainy, low contrast, etc.) and the design of images are considered to have influenced these evaluation results. It is also necessary to consider the relationship between the size of the displayed object and the resolution of the material image to represent high resolution image effectively. Though this evaluation experiment was conducted using the scene in the current program, the evaluation of the high resolution sensation depends on the improvement of the quality of 4K images.

In the scene of the space simulation, the effects of stereo dome environment such as immersive sensation, three-dimensional sensation, high resolution sensation and high presence sensation were remarkable compared to the scene of Mars panorama. As for only (iv) continuous natural distance sensation, the scene of Mars panorama was evaluated higher. In the scene of the space simulation, it is considered that the overlapped several distant point images reduced the continuous distance sensation.

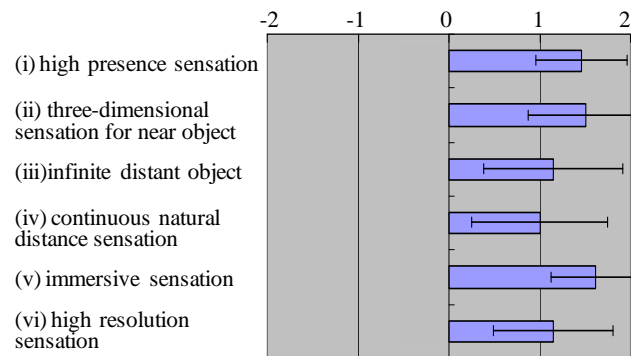


Figure 7: Evaluation of space simulation scene

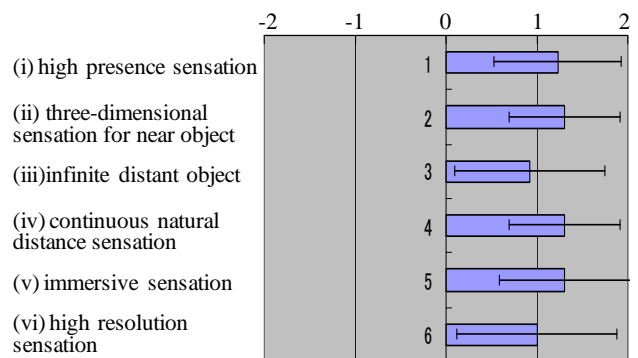


Figure 8: Evaluation of Mars panorama scene

4. Discussions and Conclusions

From the experiment, we have obtained some guidelines to utilize the high presence sensation of the images displayed in the super high definition stereo dome environment effectively.

For example, it is considered that the use of the image materials that raise the immersive sensation and three-dimensional sensation from the near view to the distant view of the audiences is one of the effective guidelines to design

science education program. Moreover, since the evaluation for the high resolution sensation was not so high compared with the immersive sensation and the three-dimensional sensation, the high presence sensation would be improved further by using the image materials from which the user can feel the high resolution sensation. From this experiment, we could confirm that the super high definition stereo dome environment improves the interest of the audiences, and then it can be used effectively to promote the science education and the science communication.

In the future work, we are planning to evaluate the effectiveness of the following scenes to develop a method of producing image contents that promote the science communication by utilizing the effects of the super high definition stereo dome environment.

i) Continuous scene from micro view to macro view

By displaying continuous scenes from micro view to macro view in the dome environment, audience can understand the Earth environment, and the relationship between the environment and our life. For example, the scene can be designed in which the view position is moved from the deep sea to the space through the sea and atmosphere, or the view position is moved from viewing carbon atom to viewing ecosystem.

ii) Scene of science simulation

Large scale numerical simulation for natural phenomenon such as atmospheric simulation can be visualized using immersive and high resolution images. The audience can understand the phenomenon by observing both the details and the whole aspect.

iii) Scene of digital archive

Since the high resolution image scanning method has become possible, the digitalized cultural assets can be visualized with high quality of reality using immersive and high resolution images.

iv) Scene of filmed image

Since the 4K resolution camera has been available, the filmed movie image can be projected in the super high definition dome environment.

v) Art works

New expression using super high definition and immersive images can be considered as art works.

References

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