Ultra-Realistic Sightseeing Images Using Digital Planetarium System

- Application For Intangible Folk Cultural Property 'Shimotsuki-Matsuri'

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Conventional images of tourist sites are trimmed off the unnecessary scenery from the whole scenery in the fixed viewing angle of the cinematographer's intention. Therefore, when people visit a tourist destination, they are often disappointed about the gap between video image and actual sight. In order to eliminate this gap, we developed the Digital Dome Theatre System in 2009. It can project ultra-realistic images of tourist sites on all the directions of the dome screen using an ultra high definition 4K video camera and projector. Firstly we used the World heritage 'Kumano Kodo' as sample data and performed the comparative experiments of dome images and flat images. As a result, we found that dome images are effective tools for enticing people to visit the tourist location. Generally, an intangible folk-cultural asset is difficult to tell the wonderfulness and to turn it into a tourism resource compared with a tangible one. Then we made a dome show program of an intangible folk-cultural asset 'Shimotsuki Matsuri' and performed open experiments at a planetarium theatre at Iida City Museum, Nagano. In this paper, we present an outline of our Digital Dome Theatre system and the experiments, and discuss its possibility for tourism.

Keywords: Ultra-realistic image, Dome Image, Planetarium, Intangible folk cultural property

1. Introduction

Sightseeing is usually understood as the physical movement of people from one place to another. It goes without saying, however, that images found on TV, in movies, in newspapers and magazines play a significant role in triggering that movement. It has been observed all over the world that tourism has increased in places shown in TV dramas or movies, which has been an interesting subject of research (Hudson & Ritchie, 2006). In addition, as most tourists take a camera with them on trips, there is an inherent bond between pictures and sightseeing, which is also a subject of research (Chalten, 1979). The definition of sightseeing can be broadened to include the purchase of videos and albums of world heritage sites, although they do not actually involve the movement of people. Faculty of Tourism, Wakayama University has set up a course for investigating this aspect of sightseeing and is currently conducting education and research on the sightseeing content of images and music.

When visiting a tourist destination, generally a gap is felt between the actual sight that the tourist is viewing and the images of that sight reproduced in photographs or movie. In the creation of images, the producer of the information, such as a photographer or a cinematographer, has specific intentions and takes images with a fixed field of view at a specific moment. In other words, he or she takes a trimmed space-time snapshot. The actual sight that the tourist is viewing, however, is not limited to a frame, but spreads out around the tourist in all directions. In addition, the season, time and climate that the tourist experiences would be different from the captured images as a result of differences in light and vegetation. In order to eliminate this gap, it is necessary to acquire a continuous, real-time display of images that capture all direction. In concrete terms, the images should not be presented on a conventional flat screen, but rather on a dome screen -like the one found in a planetarium- that continually shows a live feed of the tourist destination in its entirety without trimming or framing the field of view.

Planetariums, which recreate the starry sky on a dome screen, are the most prevailing projection system for dome images. Using nearly 90-year-old technology, these are installed in about 3000 institutions in the world, with 300 in Japan alone. In addition to main projection machine 'Star Ball'

that project stars and planets, planetarium system included multiple additional projectors, such as slide projectors, for projecting illustrations of constellations or the various graphics used in planetarium shows. However, additional 'analogue' projectors were replaced by 'digital' projectors, a simulation technology used for flight simulators was introduced into planetariums in the mid-1990s, and systems that could project across the entire dome (a 'digital planetarium' hereafter) appeared. Subsequently, with the advancements in projector and computer efficiency, resolution and contrast improved and the installation of digital planetariums increased dramatically (Lantz, 2007). As of 20 November 2011, the number of institutions with a digital planetarium in the world was 1013 (with 465 in America and 82 in Japan) (Loch Ness Productions, 2012). However, at present, since almost all these digital systems are used for the planetarium, the projected images are exclusively starry sky and the related CG images, these systems have not been developed with the purpose of projecting 'real' images of other scenes.

Since its establishment in 2008, the Faculty of Tourism at Wakayama University has embarked upon the research and the development of streaming a live feed of images of tourist location on a dome screen that would have an ultra-realistic sensation. In this paper, we outline the Faculty's Digital Dome Theatre System, which we have developed for projecting 'real', all-direction and ultra-realistic sightseeing video images. In addition, we present the results of comparative experiments between normal flat images and the newly developed dome images of tourist locations. We also discuss the efficacy of the dome image video program of the intangible folk-cultural asset 'SHIMOTSUKI-MATSURI' (Winter Solstice Festival) developed for the digital planetarium at the Iida City Museum in Nagano Prefecture. And we discuss the potential of dome images in contributing to the tourism sector, especially in the field of intangible folk-cultural assets.

2. Outline of Wakayama University Faculty of Tourism's Digital Dome Theatre

As mentioned above, the number of institutions with digital planetariums is increasing as a system to project images on a dome screen. They are however not developed with the purpose of projecting 'real' sightseeing images beautifully. The system requirements when projecting 'real' sightseeing images are as follows:

(1) High resolution
(2) Sufficient brightness
(3) High contrast

First, let us consider high resolution. The vertical resolution of high definition television (HDV) is 1080 lines. If this image is projected on a dome screen with a view angle of 180 degrees, the angular resolution for each scanning line will be 10 arcmin (1 arcmin is 1/60 degrees). Human eyesight for the resolution of 1 arcmin is 1.0 and that for 10 arcmin is only 0.1. Thus, in order to implement high resolution on a single camera and projector, a next-generation image system is necessary.

Second, the brightness. In planetariums, illustrations of constellations or commentary are projected on starry skies, so naturally a brighter image is not effective. This is why a light reduction filter is often used on a projector at planetariums. However, when projecting daytime sights, an image must be bright to be realistic. In this case, the brightness of an image projected on a dome screen is a significant problem.

Finally, the contrast. Because normal images have a narrow viewing angle, the difference of brightness in that direction is minimal, and it is easy to meet the correct exposure requirements. However, for all-direction images shot during the daytime, especially on a sunny day, not only the bright sun but also the forelight and backlight will go into the same field of view. Therefore, it is necessary to take an image with an extremely wide dynamic range. However conventional camera device such as CCD have a dynamic range at only 4 digits, not comparable to the range of human eyes. Furthermore, when projecting on a dome screen, because the screen is curved, bright images lower the contrast of the surrounding screen, making the images washed out. Hence, it is necessary to choose a camera with a large dynamic range and a projector with high contrast.

Another challenge taken on at the Wakayama University Faculty of Tourism is to maintain 'unframed time' as well as 'unframed image', by live transmitting an all-direction sightseeing image. This is possible by the Internet, however, as we are to follow the previously mentioned

constraints, transmitting the images by HDV is insufficient, and a next-generation large-capacity live transmitting technology called 'ultra high-definition image' is necessary.

On the basis of the above requirements, we studied image devices (capture, projecting, transmitting) available for sale, and as of spring 2009, we have been able to construct an optimal system. To take the images, we decided to use a 4K camera with a high-definition 4K resolution (horizontal resolution is about 4000 pixels) with a fish-eye lens. Since JVC Kenwood developed a camera that produces an output of 4K resolution images in real time, we placed a special order a custom-made fish-eye lens that matches that camera's components and can ensure 4K resolution at all field of view. In terms of resolution, even if the camera has a 4K resolution, it is not comparable to the human eye capability. Moreover, image devices with a higher resolution are not in use, and dividing capturing and projection requires processing time for conversion, making live transmittion impossible. We, therefore, decided to use one camera and one projector. To match the camera resolution, we prepared a 4K resolution projector with a special fish-eye lens installed. While several manufacturers have developed projectors, placing special emphasis on high contrast, we used a JVC Kenwood, the same manufacturer of the camera. In addition, for the transmission of the 4K resolution images, 6 Gbps ultra-wideband is necessary for non-compressed images, while, except for test networks, a broadband service like this does not exist. Instead, we used a transmission system (by NTT-AT) that used JPEG2000 codec and was able to transmit through a normal optical fibre with several 100 Mbps (Yoshizumi & Okyudo, 2010). Figure 1 is a schematic of the flow from capture to projection. The projection system of the Digital Dome Theatre we constructed was later marketed by KONICA MINOLTA Planetarium as a digital planetarium under the model name SUPER MEDIAGLOBE-II (referred to as SMGII), and the number of planetariums in which it is installed is increasing mationally and internationally.

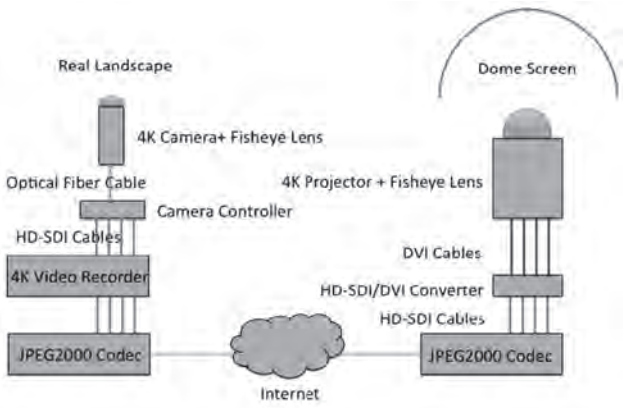

Figure 1. Schematic of the flow of Wakayama University Faculty of Tourism's Digital Dome Theatre. Taking, transmission and projection are all prepared and sightseeing sights can be projected on the dome screen in real time. The camera is only a device and the controller and recorder are prepared separately, connected by optical fibre cables (maximum length 100 m).

3. Comparative Experiments of Dome Images and Flat Images

The first operation of the completed system was a total solar eclipse that occurred on the Nansei Islands in Japan on 22 July 2009. An all-direction scene on Amami-Oshima Islands, where the total solar eclipse occurred, was taken and displayed via a live feed on dome screens in four locations on Honshu (the main island of Japan). Unfortunately, the day was cloudy, and the anticipated solar corona of the total eclipse was not visible. The audience however was able to experience and feel how the shadow of the moon moved – something that have never been experienced outside the actual location of the eclipse (Okyudo, 2009).

It is not difficult to imagine that dome images would enable a high level of sense of presence (realism) compared to conventional flat screen HD images ('flat images' hereafter), for the inclusion of the frontal as well as the surrounding images. We conducted evaluation experiments comparing dome images to flat images that were taken and produced at the same tourist location - 'Kumano Kodo/Nakahechi', located in the southern part of Wakayama in the World Heritage site 'Sacred Sites and Pilgrimage Routes in the Kii Mountain Range'. Pilgrimage routes are not limited to unidirectional photographic subjects, such as buildings like temples, for example, and the sights located along the routes are difficult to convey through flat images. In the fall of 2010, we took scenes in four

locations, from Nakahechi's Takijiri-oji to Kumano Hongu Shrine of Kumano Kodo's destination -using both dome and flat images- and edited each of them into 5-min shows called 'Walking along Kumano Kodo -Nakahechi'. These two shows were presented to the public at Wakayama University's Sakaedani Campus on 18, 19 December 2010 and Wakayama University-Nanki Kumano Satellite on 23 December 2010. On each occastion, the audience survey was conducted at each occasion with 160 valid answers (Fukuhara, 2010; Hamada, 2010).

Figure 2a shows the overall evaluation of the presentation of the dome images, which was evaluated as good by 88% of the respondents. Figure 2b shows the results of the comparison between dome and flat images. Respondents were asked which images made the subjects want to visit the actual location, and 74% of them chose dome images. Because a certain number of people chose flat images over dome images, we chose to examine the reason for their choice. Compared to the university campus results, the percentage of respondents who chose dome images was less at the Nanki Kumano Satellite, which is comparatively closer to Nakahechi, the scene of the show, so there were more subjects who had actually visited the location. Therefore, we separated the respondents into groups of those who had visited the site one time or less and two times or more and determined which images made them want to visit the location, as shown in Figures 2c and 2d. Because Kumano Kodo is not the area with many tourist sites, we judged that it would not be possible to see all aspects of Kodo in one visit. The results clearly showed that the answers in support of flat images increased among subjects who had visited Kodo two times or more. The reason for this may be the lower image quality of the dome images. Even with next-generation 4K images, the result of stretching the images onto the dome screen amounted to only 0.2 when calculated into eyesight measurements. In addition, despite the high-contrast projector, when compared to flat images, the contrast of dome images was lower than that of flat images because of the wraparound of light of the surrounding images. It is certain that the low evaluations were because of the poor quality of the images, as people who had visited the sites several times could compare these images with their actual experience. On the other hand, people who did not really know the location considered the current image quality of the dome images to be good and capable of allowing subjects to virtually experience the location. The dome images can thus be considered an effective tool for enticing people to visit the tourist location. In the comment section of the survey, the words 'realistic' and 'feeling of immersion' appeared often, and respondents also conveyed expressions such as 'When I turn my head or change my line of sight, I get a new feeling that I can't get with images taken in the past', clearly indicating that the subjects got the special features of dome images.

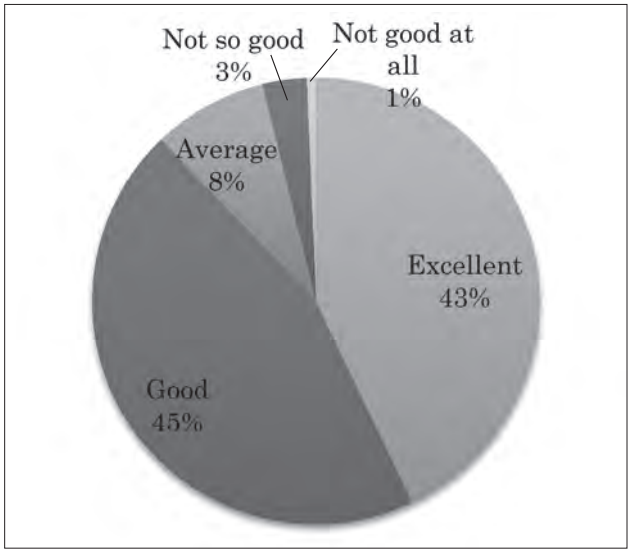

Figure 2a. Evaluation of the dome show 'Walking along Kumano Kodo 'Nakahechi'.

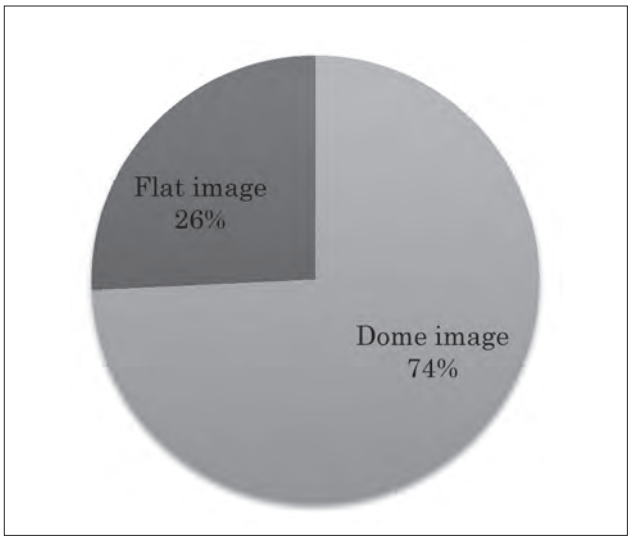

Figure 2b. Which images make you want to visit the location?

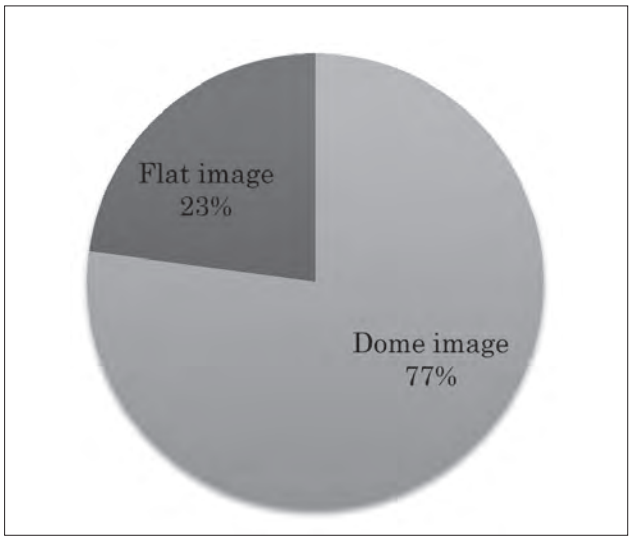

Figure 2c Which images make you want to visit the location? (Respondents who had visited the location one time or less)

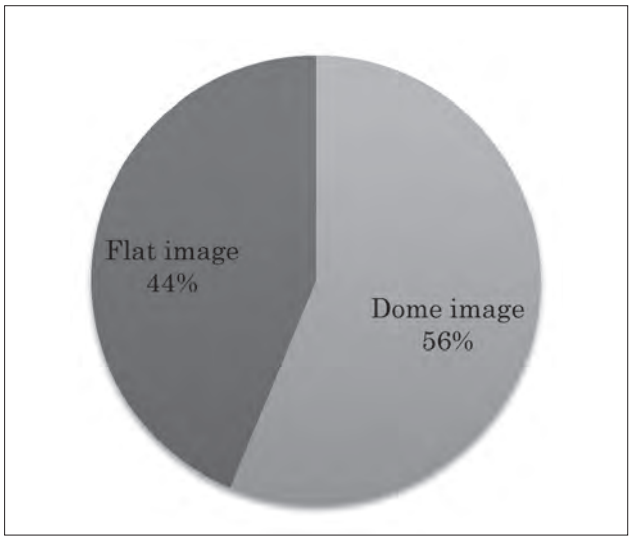

Figure 2d. Which images make you want to visit the location? (Respondents who had visited the location two times or more)

4. Application to an Intangible Folk Cultural Property in the Iida City Museum

The Iida City Museum in Iida, Nagano established in 1988 is a general museum that collects, stores and displays materials related to art, natural science and cultural science. It also has a planetarium. In 2009, over 20 years since its establishment, a need arose to update the planetarium equipment. The author Okyudo, a member of the teaching staff at Wakayama University, which has a comprehensive agreement with Iida city, accepted an advisor's role for the selection of the model.

Iida city is a municipality that is renowned throughout Japan for its green tourism, derived from its rich natural beauty, fruit production, especially apples and historical culture. It was then proposed that the planetarium would not only be a facility for the education of astronomy, as it had been in the past, but also a new dome theatre that could be used to view tourist sites such as natural features and historical culture.

In March 2010, the Digital Planetarium SMGII, which has the same capacity as that of Wakayama University's Digital Dome Theatre, was installed in the Iida City Museum. The two institutions entered a joint research agreement according to which Wakayama University's capturing and transmitting systems would be used if necessary. Following the joint research agreement, original show programs were produced, and so far six programs have been released, including four on nature, one on art and one on folk customs. In the following section, we outline the 10 minute show produced on the theme of the Shimoguri community's 'Shimotsuki-Matsuri' and report the results of its visitor evaluation.

In general, intangible folk-culture assets such as traditional festival are of limited occurrence, some only occurring one day per year. Therefore, except for events like the Kyoto Gion Festival, which serve to represent Japan, these assets are not widely known and it is difficult to turn them into tourism resources. However, Iida city has many intangible folk-culture assets that do not exist in other regions, and are being tested in various ways to turn these into tourism resources. One example of this is the lion dance 'Shishi Mai' festival, which is held in the city centre and is celebrated in each district with its own lion dance. Likewise, the 'Toyama Shimotsuki-matusri', performed at each shrine in Toyamago communities, is said to have come down from Kyoto and Kamakura rituals during the Heian and the Kamakura eras (Iida City Museum, 2006). In 1979, the festival was designated to be a Japanese Important Intangible Folk Cultural Property that maintains festivals from ancient times. Recently, when a film director Hayao Miyazaki produced the animation film 'Spirited Away', he claimed that the 'yutate' ritual (a Shinto ritual) at the Shimotsuki-matsuri provided the inspiration for the film. This did not go unnoticed by tourists. However, unlike the lion dance, the ritual cannot be moved to other locations and must

be performed at a particular shrine on certain days. It thus becomes difficult to use the ritual as a tourism resource. Furthermore, the area is inconvenient for transportation, and the fact that the ritual continues from morning through sunrise the next day and is performed in the small main building of the shrine does not permit accommodation of a large number of tourists. Thus, we thought that by producing a dome show and showing it in the planetarium of the museum, many viewers would be able to experience the historical culture preserved in this festival, hence increasing the tourism value of the region.

The Shimotsuki-matsuri at Jugosha Daimyojin shrine of Shimoguri community is held on December 13th every year. 'Shimotsuki' (the Frost Month) is the 11th month on the lunar calendar and coincides with the current December, which contains the winter solstice, the shortest day of the year. Because the rituals at the Jugosha Daimyojin Shimotsuki-matsuri are related to the winter solstice and celebrate the revival of the sun, the production was titled 'Toyama Shimotsuki Matsuri: Revival of the Sun and Life'. In the show, after the geographical explanation of the region and explanation of Shimotsuki and the winter solstice, the actual rituals are introduced with all-direction images taken on a 4K camera designed to let the visitors virtually experience the Shimotsuki-matsuri in the planetarium. Figure 3a shows the main building of the Jugosha Daimyojin shrine, where the festival is held and the 4K camera is installed. We obtained permission from the neighbourhood council to run an optical fibre cable through the main building of the shrine, enabling the installation of the camera near the hearth. Figure 3b is a single frame of the finished show - by projecting this round image on the dome screen of the planetarium, we could recreate not only the frontal but also the surrounding images.

The finished show was released to the public on March 25th 2011. During the first month when the show was free for viewing, we conducted an optional viewer survey, collecting answers from 90 people. Figures 4a–4d are graphs showing those results. First, regarding the subjects' age distribution, there was a wide range of ages and no tendencies to one age group (Figure 4a) were observed. Next, when asked about the overall evaluation of the show, 96% answered that it was good, indicating the highly effective nature of the program (Figure 4b). In response to the question asking if the effect of the dome images was good, 95% stated that it was good (Figure 4c). Finally, when asked if seeing this show made them want to visit the location, 93% showed interest (Figure 4d). Out of those, 32% actively responded that they 'definitely want to visit'. This is on the low side, but it is possible that the alternative answer, 'if I have the chance', was higher because the area is far away and the festival is held only on certain days.

This small, intangible folk cultural property, which is difficult to turn into a tourism resource, was opened as a dome image show at the museum's digital planetarium. According to the residents' evaluation, the dome images had a strong effect and received a high evaluation. Furthermore, it was clear that, just as with the scenic Kumano-Kodo show, intangible folk cultural property shows have the power of encouraging tourist activities.

Figure 3a. The 4K camera set in the Jugosha Daimyojin shrine in the Shimoguri community, Iida city. A fire is lit in the middle of the hearth for boiling water, and Shinto rituals take place in the surrounding area.

Figure 3b. Shot of the planetarium show 'Toyama Shimotsuki-Matsuri: Revival of the Sun and Life'. This round image, when projected on the dome screen, reproduces not only the frontal but also surrounding images.

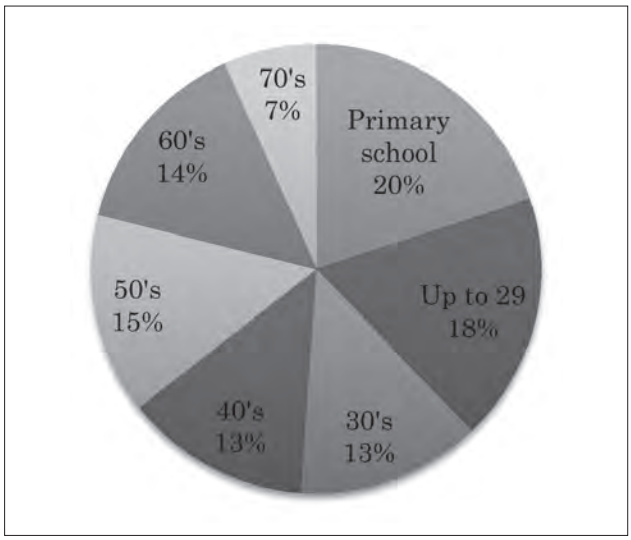

Figure 4a. Age bracket of planetarium show viewers.

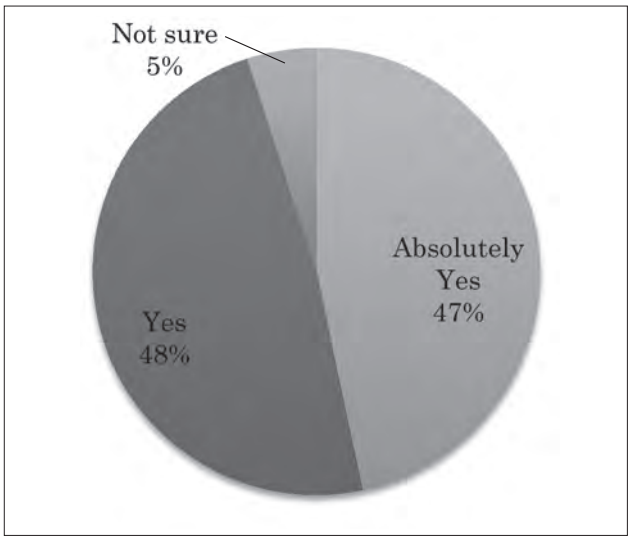

Figure 4c. Presence of effect of dome images.

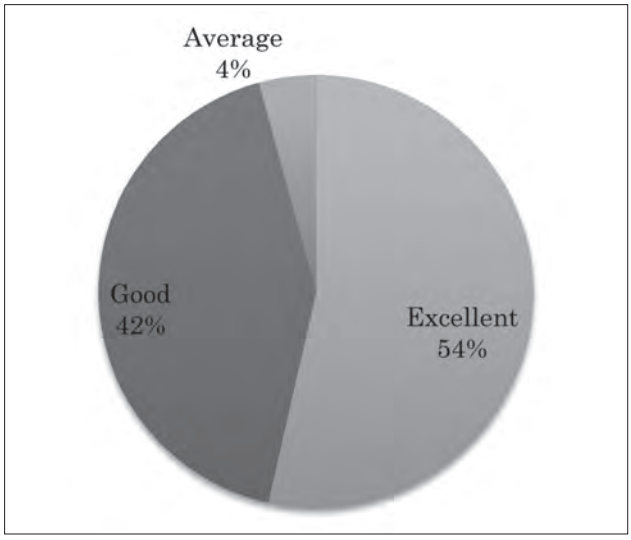

Figure 4b. Impression of planetarium show

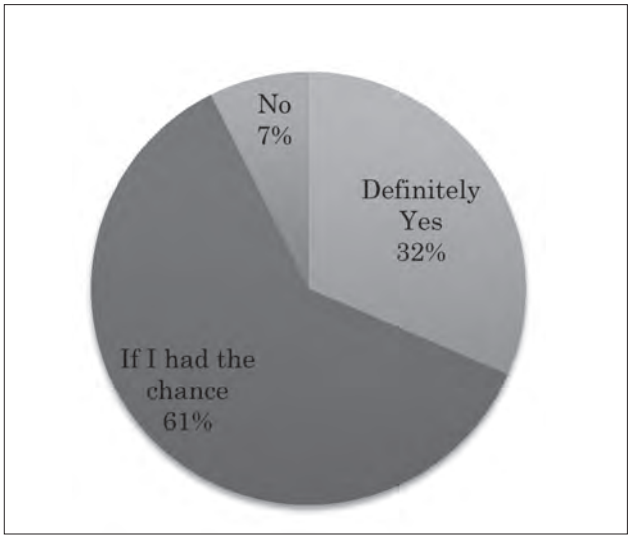

Figure 4d. Opinion poll after viewing show. 'Does this show make you want to visit the location?'

Japan Tourism Agency has examined details of the tourism situation in Iida city, along with two other cities (Hurano city, Hokkaido and Shima city, Mie), particularly focusing on residents and visitors (Japan Tourism Agency, 2011). According to this study, out of the seven tourist locations used in the survey questions, the Shimoguri area had the lowest results in tourist awareness and visiting experience. This is probably because it is located a long distance from the city centre. Although this is not an appropriate comparison as the region scene for tourists is different from that for the residents, the ratio of residents who had actually visited the area was low even when asked about the nearby 'Shirabiso Highlands'. Figure 5 shows the results of surveys on tourism strengths in Iida city according to both residents and visitors. We can see that 'Nature scenes/Rural landscape' and 'Food/Food culture' are both considered to be strength. However, when we examined the answers for 'Performing arts/Culture', the category for our show, we found a large gap between residents and visitors. Perhaps residents take a certain pride and find a sense of regional identity in their performing arts and culture, although this information does not seem to have spread outside the region. Even if a visitor spends time in the area, the role of performing arts in the community is not apparent without being there on the festival day. As mentioned before, the realistic recreation of the performing arts and cultural event Shimotsuki-matsuri through dome images in a planetarium has the power to encourage tourism. Given this, digital planetarium shows can be suggested as an innovative solution to close the gap in 'Performing arts/Culture' that was found in the Japan Tourism Agency's study.

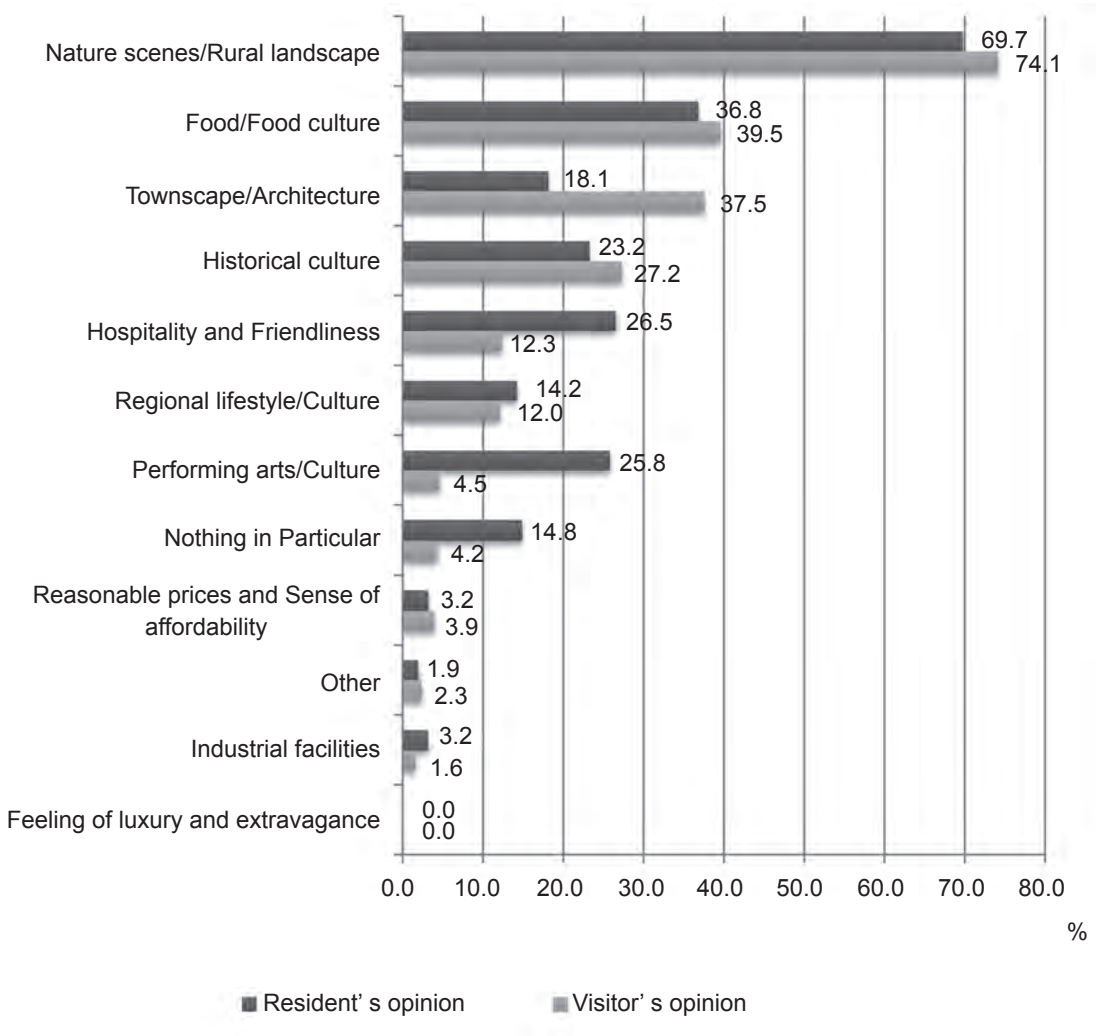

Figure 5. Iida city's strengths as a tourist location/tourism resource according to residents and visitors. (the authors have re-plotted the Diagram 30, 'Report of Examination/Analysis directed at the Formation of an Autonomous Tourism Industry', March 2011, from the Japan Tourism Agency)

5. Summary and Discussion

We constructed a Sightseeing Digital Dome Theatre system that recreates ultra-realistic site images on a dome screen without trimming or framing the field of view. By presenting images of the natural phenomenon of a total solar eclipse and the scenery of Kumano-Kodo on a dome screen, we showed that, compared to flat images, dome images have a high sense of reality and power to entice people to visit the tourist location. However, for the people already familiar with the actual location, the difference between the dome and flat images was smaller because the image quality was not high enough. Regarding the improvement in image quality, we have to wait for future technological innovations in imaging devices. At the research level, however, super high definition with resolution which is 16 times better than high definition (8K, horizontally about 8000 pixels) is already being developed. It is just a matter of time before this technology can be used for dome images. In addition, in the present state of affairs, the synchronizing process of the images would take considerable time if multiple cameras and projectors were used; hence, we constructed a system that uses a single camera and projector. Computer performance ability is improving every year, however, and real-time control might eventually become possible. There is, therefore, no doubt that there will be a resolution that surpasses eyesight for both dome and flat images. However, there is considerable knowledge regarding flat images from media, such as TV, while research on a dome image has only just begun and not much knowledge has been accumulated so far. Further research on technological issues unique to capturing, editing, projecting and transmitting dome images is still necessary.

The system we constructed did not just serve research purposes. It was also introduced at the planetarium in Iida City Museum, which is open daily to residents and visitors. The planetarium screen is already being used to display the nature, art and folk culture shows that we developed. In our cooperation with the Iida City Museum, we undertook the task of converting an intangible folk culture property into a tourism resource by using dome images. The results were positive; just as with the previous showings of dome images of natural phenomena and landscapes, the folk-culture dome images were exciting and successful in encouraging people to visit the depicted tourist locations. The Japan Tourism Agency's study clarified that there is a big gap between the perception of residents and visitors regarding performing arts/culture in the region. We propose using the digital planetarium to close that gap. In the study conducted by the Japan Tourism Agency, this gap, with small variance, was seen in two other cities besides Iida city, and we propose using the same dome image technology in other cities and villages to solve their problems. There are 3000 planetariums throughout the world, and about 1000 of them have already been converted to digital planetariums. In the institutions in which this technology has already been introduced, most of the systems' image quality is not high enough for 'real' action tourism images. Now, with 4K projectors on the market, systems with the same image quality as ours are starting to be introduced. Soon, it will certainly be possible to project 'real' action images at most institutions. At that time, the preconception that planetariums are only for astronomy education will be tossed aside, and the facilities will be used for various purposes, including sightseeing.

We have focused on 'real' action in our research and development, but there are many tourist sites for which virtual reality (VR) using CG is starting to be used for sightseeing purposes (Guttentag, 2010). In CG, there are no limitations of backlight and forelight, and images that are specifically adapted to dome images can be created. Therefore, in many places, theatres and planetariums are playing shows that use CG and allow the virtual experience of physical sights. We have also started preparations for the construction of a system that has CG features such as the addition of explanations for the images or the ability to portray historical re-enactments by combining live action and CG. However, CG is only CG and cannot compete with 'real' action when it comes to sights that include the unpredictable ecology of plants and animals and climate and astronomical phenomena. This is especially true for the content of intangible folk-cultural assets which is impossible to record without 'real' action. This point has recently been noted by researchers in the folk-cultural field, and since the fall of 2011, we have begun exchanging

information with International Research Centre for Intangible Cultural Heritage in the Asia-Pacific Region, UNESCO for collaborated research.

On 11 March 2011, our country suffered an earthquake and a tsunami of unprecedented size. Streets and towns throughout a wide region were destroyed. We recorded this disaster area in dome images, presented it in digital planetariums, and began to use it as disaster prevention education in conjunction with elementary schools. The initial results are currently being compiled in a paper. Because we realise that a disaster can destroy a landscape in a matter of minutes, we want to emphasize the necessity of recording all tourist locations in order to preserve them for the future, not as one-directional flat images but from all directions, regardless of whether they are tangible or intangible.

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Notes

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