On the structuring of a model for multiplying exhibition experience through utilizing digital technologies

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Abstract:

This paper discusses a research report for structuring a model for multiplying exhibition experience through utilizing digital technologies such as Virtual Reality(VR) and game design creation based on two field research projects.

One of the projects is about achievements and findings of exhibition practice conducted in spring 2012 at Kyoto Museum for World Peace, Ritsumeikan University. The other is about preparatory stages of a project of which the main purpose is to structure a game-inspired Virtual Reality system in which one could experience a digital simulation of Nagasaki's *Dejima* in the Edo Period in Japan through multi-modal interactivity.

Keywords:

Cultural heritage restoration, Virtual Reality, Mixed Reality, Digital games, Multimodal interaction.

1. Research Report on the project of Exhibiting Practice Space in Kyoto Museum for World Peace, Ritsumeikan University

For examining furthermore the first stage of the practical exhibiting concept, practical surveying and research was conducted through participation as exhibition advisers in the spring 2012 exhibition at Kyoto Museum for World Peace, Ritsumeikan University.

The theme of this exhibition was based on the future of energy and was primarily aimed at teenagers to deepen their understanding of nuclear power and radioactivity in the wake of the nuclear accidents triggered by the Great East Japan Earthquake. Serving as preparatory work for the *Dejima* Project by mobilizing digital technology and video-game-inspired induction methodology into exhibit development, through the incorporation of interactive visual technology with playful design in addition to conventional one-way information presentation, such as through the use of panels and exhibits, the interests and motivation of visitors can be raised, and realization of memorable exhibiting can be considered.

Five meetings were held with staff members involved in this exhibition in which it was decided to conduct two projects: A) Production of interactive visual systems; and B) Production of tour experiencing design for exhibiting and viewing. Details of the projects are as follows:

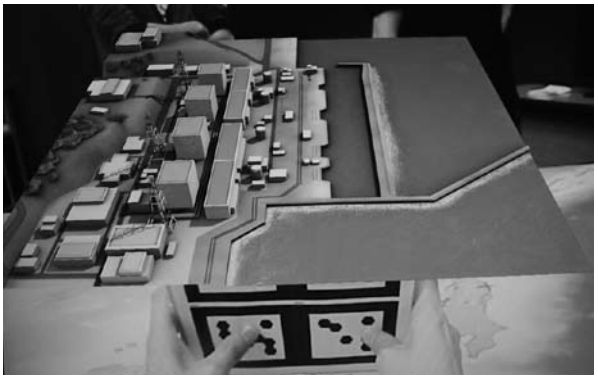
Project A: Production of interactive visual systems

With respect to the production of interactive visual systems, the development of the following two exhibiting functions were proposed as achievements for the current Japanese academic year: 1) The nuclear power plant VR experience: a system utilizing Mixed Reality(MR) feature synthesizing actual and Computer Graphics(CG) visuals accurately in real-time, enabling the experience of a virtual nuclear power plant; and 2) The experience of seeing and detecting-radioactivity: an interactive exhibiting panel system with pseudo radioactivity detection functions using safety infrared.

1) With regards to the nuclear power plant VR

experience system, the system and contents have been developed. Visitors wear a Head-Mounted Display (HMD) to experience an aerial view of the entire map of Japan before approaching the Fukushima nuclear power plant from the sky above. As the altitude is lowered above the power plant, a transition is made to a three-dimensionally displayed virtual model, and on a scale of the entire site of the nuclear power plant, the positional relationship of the sea and buildings can be recognized intuitively. The specifications, additionally, allow the user to proceed to the actual size of a single building structure. In this building-scale experience, the specifications allow for switching through the multiple layers between the building and the reactor core to take a closer look at its structure. Figure 1. shows scenes of experiencing the system.

(a) Participant and the system



(b) View from the participant

Figure 1. Nuclear power plant VR experience system

2) Regarding the interactive exhibit panel system with infrared radiation detection features that was created for this study, infrared light emitting diodes are embedded inside of the panel display to resemble a radiation source. An electronic device which simulates a Geiger counter then helps to understand the reality of where radioactive material tends to accumulate as well as the relationship between radiation intensity and distance from the radiation source. By using infrared lighting which is harmless, yet, possesses the characteristics of radiation, a safe interactive experience becomes possible. It is also possible to visually check the infrared light-emitting sources by using a mobile phone or a digital camera. Depending on the exhibits prepared with mechanisms to observe infrared lighting, which cannot be seen with the naked eye, it is expected that, regarding the general scare towards radiation, proper knowledge along with the aspect of thinking calmly, through this infrared simulation experience, are communicated. Figure 2. shows scenes of experiencing the system.

(a) Using the device

(b) Multi-user participation

Figure 2. Virtual Geiger Counter

Additionally, students in the Graduate School of Image Arts at Ritsumeikan University have been involved in the aforementioned development case efforts, and a cross-disciplinary mechanism aimed at returns and circulations to research education are being examined. A prototype system is being worked on so that knowledge and information attained through the case developments are reflected in the virtual *Dejima* experience.

Project B: “CORO-ga-City” Production of tour experiencing design for exhibiting and viewing

Incorporating a playful method or more specifically, a participant guidance method evolving from video games called gamification, into the form of the viewing experience is proposed. This does not refer to the digital application of digital game interfaces in traditional serious games and e-learning approaches, but rather, to the area of applying video game designing itself into the real world. The fixation points of design are “the fundamental elation of the heart and desires to overcome obstacles, altercations, and crisis.” (Gonigal, 2011).

Particularly in this exhibition, although time was limited, three experimental points were scheduled as game design for the real world. These include:

1) Design for empathy by way of the act of cutting out paper.
2) Production of assignment field using dice.
3) Design of the act of scrapping by utilizing clippings of dice.

Specifically:

1) Design for empathy by way of the act of cutting out paper

Based on past records, many of the visitors to Kyoto Museum for World Peace at Ritsumeikan University are to be elementary and junior high school students on school trips. Therefore, the presumption is that those regarded as players for this project are of similar age, are well acquainted with each other, and either act in assigned groups or in groups of friends. To have these players participate in the exhibiting experience from a game approach, it is firstly necessary to create a subject for self-projection. As a ritualistic act to have participants empathize, it was decided that developmental plans were to be cut out from paper, and hexahedrons would be made. This dice-shaped player character would then be used in the various assignment fields interspersed within the exhibition, in order to attain affection.

(a) Development

(b) Completed dice

Figure 3. Design for empathy by way of the act of cutting out paper

2) Production of assignment field using dice

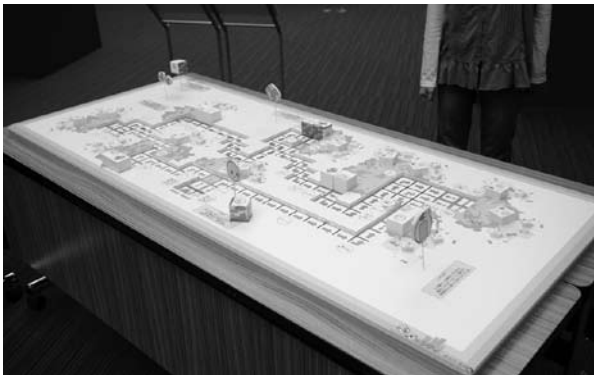
Using the dice as a player character, the plan is to base the exhibits on the information written on the exhibit panels in the following ways:

A) A partitioning game exhibit for exposure protection in which up to four people can take part.
B) A physical sensing exhibit for nuclear fission caused by neutrons and uranium in which up to four people can take part.
C) A leaflet board expecting that the dice, after being taken home, would be reused to propagate the contents of the exhibition at home.

The use of the dice is different in each situation allowing for uniqueness in the exhibits and leaflet board.

3) Design of the act of scrapping by utilizing clippings of dice

The dice, as the player character, are constructed on the construction table situated near the exit of the



(a) Overall view of CORO-ga-City

(b) Multi-user participation

Figure 4. Production of assignment field using dice

exhibition. Along with their construction obviously comes the excess paper which is collected into a portable mailbox with a mail slot. Participants continue to view all exhibited panels while they make rounds of the entire exhibition, using their dice to experience the playful exhibits.

The flow line of the entire hall ultimately leads to the side of the exit, which is set so that it appears in the rear-side of the aforementioned mail slot. Although not seen when the excess paper is initially collected into it, on the rear-side of the mail slot is a drawing of a cross-sectional view of the Earth. The paper that the participants place into it functions as an exhibit itself, representing waste buried deep underground.

Further, the dice that participants construct symbolize sources of their own and of their families' health, living situation, wealth, and energy, and the exhibition as a whole aims to have participants realize that they are involved in the project as the subject of "negligence and the price to pay for it."

a) Posting mouth

(b) Lamination

Figure 5. Design of the act of scrapping through utilizing clippings of dice

2. Research report on the project of virtualizing "Dejima"

Let us begin by setting out the background of this project.

With the advancement of digital technology, visual expression has shown a variety of deployments in recent years. In the fields known as visualization and information aesthetics, however, the visualization of impacting scientific data, restoring lost cultural

property, and structural models of urban planning have increasingly shown global activity forming a horizon of new possibilities for visual expression.

An example case of this is the work of Toppan Printing Co. Ltd. in which the Machu Picchu ruins of the ancient Inca civilization are reproduced digitally and shown in three-dimensional form across a large screen. This VR production, "Machu Picchu – The Holy Land of the Sun", was screened during the Inca Empire Exhibition held at the National Museum of Nature and Science in 2012.

On the other hand, Digital games such as *Daikokai Jidai Online* [Age of Discovery Online] (Tecmo-Koei Games, 2005) and Patrician IV (Kalypso Media, 2010) currently do exist and depict themes of the same era. As the object of playing in this project, however, focuses on economic expansion and the naval battles and trade relating to it, the perspectives of merchants who travel sea routes freely as well as regional governors who can overlook the land they administer will be depicted. Conventional VR visual works such as those previously mentioned are committed to the realization of immersive visual experience leading mainly to the three-dimensional world. In contrast, this project is unique in that it attempts to not only achieve the immersive experience and reproduction of the spatial *Dejima*, but to use this virtual environment as a foundation to subjectively realize an interactive narrative of the activity, interaction, and social and historical experiences of people who were isolated from the rest of the world.

Investigation findings, through research sessions reviewing them by aurthors, reveal that the concept model containing a view to both the multi-layered structure using VR and video-game-inspired story deployment was elaborated. More specifically, it is necessary to act on the virtualization of *Dejima* from the following perspectives:

- The formulation standard of visualizing by narrative-modeling through visuals for international exchange.
- The level of VR-type development and designing of interaction technology corresponding to the above.
- The structuring of a dynamic worldview and advanced RPG-type context onto a virtual environment.

In response to this 1) scale settings of the virtual experience; 2) implications and preparatory investigations of system development; and 3) possibilities of structuring experience-based environments that are not reliant on devices shall be implied. Incidentally, it is clear that these perspectives are mutually related. At this stage, however, the authors agree to refrain from constructing a comprehensive perspective which generalizes these elements, and to form a bottom-up type survey and discussion.

(1) Scale settings of the virtual experience corresponding to the subdivisions of the external environment surrounding *Dejima*

In digital technology environments, conditions bound to a single line of time, such as film screenings, or in other words, non-linear story conditions as opposed to linear story structures, become possible. Additionally, a platform for medium of expression which allows a wide range of plots to expand while mutually interacting becomes possible. Such plots include: recovery types such as incident-resolution; circulation types such as problem-overcoming; and further, equilibrium recovery types and balance achievements types. This, however, also indicates that scale settings in transition states are necessary in order to allow the story to parallel in multiple tracks and to expand dynamically. With this in mind, it was decided for developmental purposes to organize *Dejima*, a place in the world thought of as developing multi-layered stories, in a further accessible state by classifying it into several scales, or major categories in transition states.

Specifically, it was confirmed that the following three standards overlap each other regarding the environment surrounding *Dejima* according to historical literature collected: 1) communications with

the environment surrounding bygone international relations of *Dejima*; 2) external traveling means within Japan from *Dejima*; and 3) the internal world of *Dejima*.

In response to this, it was agreed that division of the classifications of experience scales and associated items in, for example, the following ways was possible:

(SCALE 1) Exchanges with the outside world during the Age of Discovery

1-a) International trade such as that between Portugal and the Netherlands (including interaction with the East India Company in Batavia → Laborers
1-b) The introduction of Christianity (including Francisco de Xavier, the Shimabara Rebellion, and clandestine Christians)
1-c) The Napoleonic Wars
1-d) The Phaeton Incident / The Siebold Incident
1-e) The introduction of Japan by Kaempfer and Siebold

(SCALE 2) Within Japan

2-a) Nagasaki *bugyo* (officials of the Tokugawa Shogunate)
2-b) Shogunate worship
2-c) *Tojin yashiki* (Chinese residential district)
2-d) Relations between priests and prostitutes

(SCALE 3)

3-a) Business dealings
3-b) Festivals – Feasts of change, Japanese-Dutch winter solstice, badminton, billiards
3-c) Japan-Dutch winter solstice
3-d) Offerings for Edo
3-e) People – Chieftains and other officials, Chief Factor (Capitão), ship captains, laborers, prostitutes

(2) Implications and preparatory investigations of system development

This can be summarized as a possible solution to combining immersive VR experience with on-site virtual experience using Mixed Reality. Specifically, the function of immersive VR experience which covers one's whole field of view with virtual CG images can be utilized to realize, to their fullest extent, the degrees of freedom in the time axis enabling the experience of the changing of times at preferred speeds and spatial perspectives such as traveling to and from other countries from the point of view of the traveler, or looking down on the earth from high altitudes.

In addition to this, by utilizing the features of on-site virtual experience using Mixed Reality which enables subjective viewing of seamless CG and actual landscape visuals, observations of reconstructed buildings in the *Dejima* district as well as its surroundings and buildings which are either left unreconstructed or are impossible to reconstruct, can be experienced synthetically using CG technology.

These technical factors and requirements for the structuring of a VR system are generally classifiable as follows:

A) Image generation technology, which includes
Real-time features, stereoscopic image generating functions, multiple display functions for wide-view implementation, and advanced reality.
B) Image displaying technology, which includes
Immersive image display functions, stereoscopic display functions, and wide-view display functions.
C) Interactive operation technology, which includes
User interfacing with three-dimensional space.
D) Software development environment technology, which includes
Programming and integrated development environments for interactive three-dimensional CG contents development corresponding to various VR system interfaces.
E) Data management and sharing technology, which includes
Data communication technology such as databases, servers, and the internet.

As the specifics of the virtual *Dejima* experience are being considered at present, it was decided that particular system configurations would not be

hypothesized in the current Japanese academic year. Rather, the Graphic Workstation (GWS), which is a highly-functional computer possessing enhanced graphic capabilities to serve as a platform for content development and operation, and the Central Processing Unit (CPU) and video cards that it comprises, along with stereoscopic devices, technology and product trends in the software development environment are to be examined for their vast potential.

Surveying of technology and product trends was carried out in hardware and software regarding: 1) image generation technology; 2) interactive operation technology; 3) software development environment technology; and 4) image displaying technology. Rather than limiting to general product surveying using the internet, technical personnel of multiple domestic trading companies as well as VR solution vendors were interviewed.

The findings revealed that stereoscopic displaying using multiple screens which, in the mid-2000s, was not possible without a special configuration synchronizing video card images to multiple GWS connected to a network, are now, with the advancement of multi-core and multi-threading CPU developments as well as the creation of Graphic Processing Unit (GPU) multi-graphic cards, the current environment enables cylindrical screen displaying and CAVE, a device which projects three-dimensional images in a room to four walls -the floor, front, left, and right ends- with only one GWS. In addition, products such as stereoscopic projectors are now available at reasonable prices and offer high performance, allowing a larger degree of freedom concerning the structuring of a VR system. Thus, all technical surveying necessary for the structuring of an experimental system was completed.

With this surveying in mind, an experimental system platform was considered in advance through possible sharing of facilities with related research projects, and specifications and experimental structure were designed for said platform system. This system shall hereinafter be referred to as VR Experimental System. In addition to the basic functions of GWS such as its CG drawing capabilities and CPU performance, a certain degree of portability ensuring flexibility with setting and installation were prioritized, which shall be described in particular.

According to the findings, it is possible to achieve a structure enabling stereoscopic images to be presented on multiple screens emitted from a single computer, which leads to increased possibilities in relocation, a challenging task to carry out with a large rack-mounted computer cluster. A contemplation of this study is to aim for a variety of VR usage. From this perspective, while compactness to the extent of effortless portability may not be necessary, the authors conclude that there is a need for system specifications that allow enough portability for instances such as museum events and exhibitions where users would not have to physically attend a virtual reality equipped facility, but rather, a venue where the system is set in an applied domain closer to the field involved.

As far as up to ten years ago, a VR system would have cost tens of millions of yen. However, based on these findings and after collaborations with the VR solutions development firm Solidray Co.,Ltd., it is estimated that a 60 inch three surface portable screen system is achievable for under 5,000,000 yen, and would possess highly practical design specifications such as: 1) video generating performance functions; 2) stereoscopic display functions; 3) wide view display functions; 4) multiple screen display functions; 5) setting portability; and 6) software development environment. As an achievement for the current Japanese academic year, the design specifications for the aforementioned VR Experimental System as a whole, and, as an exploratory structure, a GWS was introduced as the smallest possible core to be used, at minimum, for the VR Experimental System.

Basic specifications of the GWS include implement-ations of the Intel Xeon six-core processor as the CPU and the NVIDIA Quadro 5000 as the GPU. With the use of the manufacturer's Scalable Link Interface (SLI) feature, two or more video cards are linkable together. Although application is for one card,

hence two sides this time around, the configuration can be expanded to two cards enabling four-sided stereoscopic display. With four sides, structuring of a CAVE, in which the whole room functions as a screen, becomes possible and has resulted in the designing of a basic system corresponding to a variety of display environments.

There are two choices regarding stereoscopic display function; one being stereoscopic vision with LCD shutter glasses, and the other being stereoscopic vision with polarized glasses. The polarized glasses option, however, requires a specialized screen known as a silver screen, and after considering the aforementioned adaptability needed for external exhibiting, it was decided to pursue the LCD shutter glasses option for its flexibility with screen material. Furthermore, with the LCD shutter glasses option, stereopsis is achievable through a visual expression method known as projection mapping, which realizes various forms of visual expression by superimposing various buildings and objects. For the *Dejima* Project, the three types of specifications of VR experiences possible through the use of this system are: 1) virtual experience using Mixed Reality(MR); 2) immersive VR experience; and 3) reality projection through projection mapping.

(3) The potentials of structuring an environment non-dependant on devices

When viewing this project as a digital game, the ultimate goal would be to fuse it with a VR system. However, in the stages leading up to the goal, the aim should be to structure a balance between the player and the world conducting a spiral model of development through disclosure and test-playing on the internet as much as possible. Therefore, development is desirably non-dependant on special devices, media, or game engines.

Ultimately, those that function with web-browser plug-ins, such as Adobe Flash and Unity, were selected allowing production by virtualization of changes in IO and device forms, such as tablet-type, cellular-type, and conventional PCs, along with dependence on Windows and Apple operating systems. In the current stage, it has additionally been confirmed that the playing of software manufactured under both Flash and Unity development environments on web-browsers, and through multiple operating systems, show no problems.

3. Arrangements for Further Research

In light of the results, preparatory model structure, and practice of this study, issues were sorted as the next step to the consideration of the question of structuring of a model for multiplying exhibition experience through utilizing digital technologies

For the project of Exhibiting Practice Space in Kyoto Museum for World Peace, Ritsumeikan University

Project A: Production of interactive visual systems

Many of exhibition forms showing visual images assume that there is a screen of this or that kind between the world of the visual images and the viewer, and even exhibition forms presenting real object(s) simply provide the condition in which the visitor cannot touch those objects since they are protected by glass cases or something. In contrast to such forms, exhibition forms utilizing MR technology can offer the space where the visitor can experience multiplied worlds related to the subject in question, moving freely according to her or his subjective viewpoint, and furthermore she or he is allowed to touch and manipulate them virtually.

The kind of interaction in MR systems can embody the type of design for museum exhibition that could offer a more sensory-conscious experience to the visitor than diorama models can. Specifically speaking, it would be much easier to change the content to be exhibited relatively swiftly, and to realize the effect of immersion into the universe exhibited and of enhancing visiting motivation through changing scales of exhibited virtual worlds without drastic rupture.

On the other hand, one can refer to those

problems, or tasks to be solved in a further research. Firstly, the cost by which mechanic systems are to be introduced and to be operated is still a question to be considered. In addition, since such systems as MR systems are not easily available, physical assistance would be needed for operation and outfitting. Also because they are still highly expensive, one cannot leave the system kept in exhibition space without proper attendance. Second, since MR systems are supposed to be a part of the whole exhibition space, one has to consider how they should be installed most effectively in each case, whose procedure might be more simplified in future design.

Using infra-red light instead of radiation, both of which are invisible but are essentially different in terms of effects to human body, this design adds interactivity to the panel exhibition, stimulating the visitors' motivation, which is clearly shown by the results of questionnaire for the visitors.

However, how one can utilize this sort of panel device considerably depends on what is exhibited and what is intended in the exhibition project in question. In the exhibition the authors engaged in this time, what is to be represented, namely Geiger counter, exits in reality, and what one should do is just to turn out a proper alternative device. However, in general, how and what an interactive panel device can do needs further consideration.

Project B: "CORO-ga-City" Production of tour experiencing design for exhibiting and viewing

One may say, how one can utilize game design for exhibition space is in general a question to be examined with much deliberation. Basically, game design is expected to be created to produce some positive psychological effect and provide a sophisticated immersion experience. Then it is not so easy to utilize such game design for exhibition since to what extent it can match what is pursued in exhibiton because there are cases that any positive psychological effect or immersion experience is not what is intended in exhibition. As a result, previous attempts such as "Kaiyukan NintendoDS Guide" in Osaka Kaiyukan (2010) and "Anagura-no-uta" in Miraikan (2011) simply place a video game device in museum or uses the device to prepare the narrative-style introduction into the exhibition channel.

However, this time, since the exhibition mainly concerns with the problem of radiation after the Great Earthquake of Eastern Japan and the very viewpoint of the the organizer and planner of the exhibition in Kyoto Museum for World Peace would be a important message to the society, such phrases as "video game" and "playing" could possibly cause by themselves some unnecessary association misunderstanding, and immersion experience would itself misguide the intended orientation of the exhibition project.

This difficulty was approached in our design in the way that what might be called the "4 eyes" interface, which mean that recently video game design tends to take in to consideration not only the two eyes of the player but also the eye(s) of the third person watching the playing game behind the player. Mobilizing this "4 eyes" approach into the exhibition space, we attempted to multiply the participatory experience in the corner we designed. At lease this interface design produced some effective involvement along the line of the concept of the exhibition although it should be examined with further application

For the project of virtualizaing "Dejima"

As previously mentioned, given that the perspectives of this study are divided, to a certain extent, into the multi-layered structure using VR and video-game-inspired story deployment, subjects are hereby organized.

First, issues are sorted from the point of view of the multi-layered structure using VR. As part of a government-lead *Dejima* restoration project, massive long-term efforts which include excavations and purchasing of surrounding property are being made to restore lost landscape and architecture. However, since recovery of portions lost due to the widening of rivers is almost impossible, it is believed that virtual restoration

by implementing Mixed Reality functions is effective. Further, as the architecture of *Dejima* has a history of going through various transitions between 1636 and 1859, restoration is presumed based on the landscape of the late Edo Period. In other words, the role of the VR/MR systems in a situation of this kind is to provide a function enabling users to experience a continuous transition in a given period of time.

In addition, the importance of realizing various data visualization functions, such as the diverse international exchange surrounding *Dejima*, the traffic of people, trade, and the introduction of science and religion have become apparent.

Samples of detailed specifications for a pilot case shall be indicated as follows:

1) Structuring of a fundamental database regarding the traffic of goods, people, and culture.
2) Utilization of virtual experience using Mixed Reality features to superimpose virtual images so that they complement reality.
3) Utilization of immersive VR experience features to realize experiences beyond spatial and temporal limits.
4) Utilization of multi-modal user interface features to appeal to multi-sensory experience.

It is believed that visualizing these and conveying them clearly and intuitively will lead to a fulfilling of the virtual *Dejima* experience.

Next, issues are sorted from the point of view of video-game-inspired story deployment. In the research for the current Japanese academic year, surveying has consisted of determining, from a game-type viewpoint, the perspectives of: 1) a storyteller communicating a story; and 2) a camera which shoots it objectively. The points of issue are as follows:

1) The viewpoint of the storyteller

Even in such a limited area as *Dejima*, the people involved are not just limited to those of Japan and the Netherlands, but to people of other countries such as the United Kingdom and China who served as a waypoints.

In particular, the fieldwork conducted in *Dejima* unexpectedly revealed a history of workers who were taken there from Indonesia, enjoying badminton and billiards, which leads to the assumption that, while these people may have one day suddenly been brought over to Japan, their days may not have always been spent in agony. By utilizing this third perspective for the main role, and therefore, as the player character, as is the case for modern day people who visit *Dejima*, it can be expected to function advantageously as a perspective of visitors to a different world. In a linguistic sense, by expressing the foreign languages of Japanese and Dutch languages as languages that couldn't be comprehended, the portraying of *Dejima* from the viewpoints of these workers can be expected.

2) The viewpoint of the camera

In this study, and in particular, the study of the abstract methods of depiction in *ukiyoe* prints of *Dejima*, have proven to be meaningful especially with regards to the handling of cameras. The perspective of Japanese-style painting, which represents *ukiyoe*, is of an orthographic ("Ortho", meaning correct or undistorted in Greek) non-perspective style. Citing from our vision, an example of this would be seen as an expression method as if to zoom in from afar. This approach can be said to be commonly seen in the 2D era of games represented by modern video games such as Super Mario Brothers (Nintendo 1985).

Representations of buildings depicted in *ukiyoe* show directly through the roofs and ceilings allowing those who look in to the large space to instantly comprehend the drama that takes place inside.

The abstraction technique and camera perspectives to be used are therefore selected by considering the direction of visualizing *Dejima* as it is portrayed in *ukiyoe* rather than just reproducing it from a realistic point of view.

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