Information Modelling and Knowledge Bases XXXIV
M. Tropmann-Frick et al. (Eds.)

doi:10.3233/FAIA220491

Virtual Art Exhibition System: An Implementation Method for Creating an Experiential Museum System in a Virtual Space

Tsukasa FUKUDA[a,1] and Naoki ISHIBASHI[a]
[a] *Graduate school of Data Science, Musashino University*

Abstract. In order to provide art exhibitions in a virtual space which integrates various data of an art museum and gives an emotional experience, the Virtual Art Exhibition System is proposed. This research uses a multi-database called Artizon Cloud to display museum data, combinate with technologies called Data Sensorium and Torus Treadmill to project images and enable visitors to walk around the virtual museum. Moreover, the virtual museum will exploit the user's intentions and be personalized, automatically generating further art exhibitions.

Keywords. museum systems, virtual reality, virtual museum

1. Introduction

The social transformation with information technologies is rapidly widening in the world even for public facilities. It is also the same for the museums. Museums in the world have started importing the transformation, such as digitizing the art information archives [1], and photographs of artworks beginning to be digitally archived [2,3,4]. As an example, Google's "Google Art Project" is an archive of extremely high-resolution digital images, with about 600 museums and galleries participating worldwide [5]. For another example, archiving the museum layouts through the analysis of visitor behavior [6], archiving the traditional culture and the staging of new experiences through digital technology [7] are the examples of the current entries of digitization in museums. As shown here, there are numerous things that digital implementation can do to museums.

The virtual (VR) museums are also getting lots of attention. Although there are various definitions of the term "virtual museum" [9], in this paper, a virtual museum is defined as making digitized objects available online or using high-tech equipment such as VR glasses to make the visitors feel as if they are in a real-world museum [8].

With the increasing popularity and acceptance of virtual reality technology, especially in the field of museums, virtual museums have once again become the focus of attention [9]. Until today, there have been art museums reproduced on websites such as the online museum services named HASARD [10], which is a service that displays archives and details of artworks on the website and VIRTUAL MUSEUMS [11], which

[1] Tsukasa Fukuda, Musashino University, 3-3-3, Ariake, Kotoku, Tokyo, 135-8181 Japan; E-mail: g2150002@stu.musashino-u.ac.jp.

is a service that museums around the world are displayed on the map, and the user can watch tour videos and 360-degree images of each museum. In this way, the benefits of digitization have taken us to a stage where visitors can enjoy artworks regardless of the artwork's location and the user's location. Not just an advantage for users, while many museums around the world have been forced to close temporarily due to the spread of COVID19, a "virtual museum" that allows visitors to experience the artworks displayed in the museum via internet can be said to be a lifeline for serving museum services under the current pandemic circumstance. Although, while there are many virtual museums as the examples above, there is still no museum that projects the artworks in a form of real size. In general, real-world museums display multiple artworks in the room and provide the space and the experiences to the visitors. The concept of a VR museum with the advantage of being able to view artworks on the internet is very positive, yet we believe that including more sense of reality to this concept would create an even better experience for users. According to [12], the author advocates how important a sense of reality is to the museum experience. The author claims: On a video screen, a painting has no texture, and when three dimensions become two, something is always lost. Therefore, realism could be a major keyword in the construction of a virtual museum. Thus, we have chosen to create a VR museum that provides newly designed art experiences and to also pursue a sense of reality.

In this paper, we will propose a virtual museum which will be called a Virtual Art Exhibition System.

2. An Experiential Museum System

2.1. Art Sensorium Project

To enhance the art experiences of art museums, the Art Sensorium Project was launched at Musashino University in 2020(Fig.1). Current research goals of the project are as follows: 1) system design and implementation of a multidatabase system that integrates multiple digital archives of art collections, and 2) system design and implementation of a virtual exhibition environment that provides more experiential and emotional impact to an individual. In this paper, we propose an experimental system design and implementation of a Data Sensorium application for Artizon Cloud [1] that 1) automatically displays artworks, 2) extracts users' interests, and 3) automatically re-displays artworks based on the extracted interests.

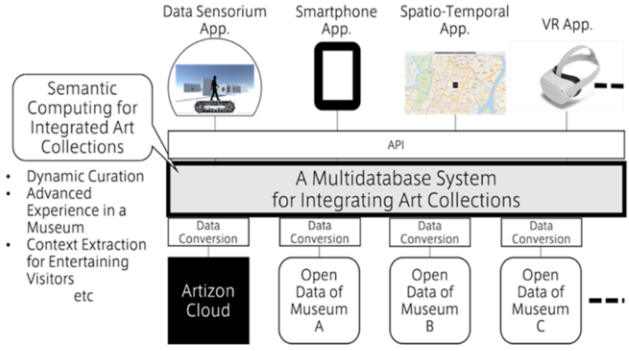

Figure 1. An overview of Art Sensorium Project

2.2. Virtual Art Exhibition System

The goal of the Virtual Art Exhibition System is to provide art experiences to each user according to their interests and intentions. Toward the goal, we aim to pursue reality and provide a dynamic virtual museum experience in cyberspace based on the idea "Emotional Excitements" which we defined as something that visitors can truly enjoy and be moved by.

By using the multidatabase system, where many artworks are converted into image data, it is possible to display numerous artworks in a virtual space which would not be possible in a physical museum. Furthermore, the Virtual Art Exhibition System will exhibit dynamic and automatic curation according to each visitor's intention and interests. No matter the user's and artwork location, this could provide an "Emotional Excitement" that goes beyond the world. Below shows the features of the proposed system:

1) Personalized Exhibition generated based on the user's physical characteristics

Each user will be asked to input the height information before viewing. Then the system will be displaying artworks adjusted to each user's height and the height of the eyes so the users could easily view the artworks in the best position.

2) Personalized Exhibition generated from the user's intension and interests

The concept of personalization is extracted from the user's interests and intentions. The definition of "interest" and "intention" is complex, and there are various ways to extract user interest. Such as letting the user input, recording the user's walking trajectory, the time the user stopped in front of the artwork, user eye tracking, etc. In this system, we defined "user interest" as the time the user spent in front of the artwork.

By combining these factors, visitors will be able to experience an even more immersive experience in the virtual museum, and a unique "Emotional Experience" that could only be achieved in virtual space.

2.3. Exploiting users' intentions and generating art exhibitions

As a premise, we define that the more the user spends time in front of the artworks, the more the user prefers the artwork. In other words, it can be said that the user's behavior shows the user's preferences. In this system, we succeeded creating **2) Personalized Exhibition** in which generating and exhibiting the artworks related to the user's intention by calculating the user's staying time in front of the artworks. Firstly, a set of artworks will be randomly exhibited in the exhibition room. While the user is walking around, the artwork that the user viewed the longest will be extracted. Secondly, the new set of related artworks will be searched from the database, based on the chosen artwork (which was most viewed from the previous set) (**Figure 2**). Related artworks are defined as: artwork that is from the same period, author, and country to the chosen artwork. Finally, the new set of the related artworks will be exhibited in the virtual museum. This curation function is designed as a database user interface in the virtual space, so the intension is converted to a query in SQL form. When a user spends more time in the virtual space for viewing many sets of artworks, more precise interest for artworks could be extracted for searching in detail. There are many possible approaches to re-design the curation function such as semantic computation or spatio-temporal computation, although these more advanced methods will be discussed in the future.

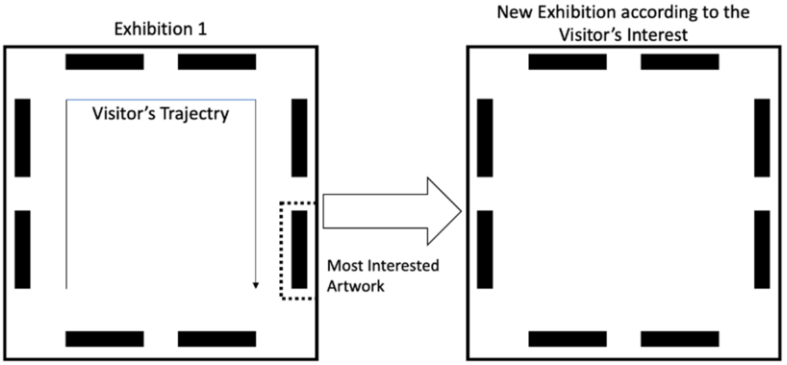

Figure 2. An implementation of the *art exhibition system*.

3. Implementation Environment

To implement the actual size exhibition for the proposed system, the proposed system uses a dynamic full-scale projection system called Data Sensorium which can provide realistic virtual exhibitions of artworks. The next section will explain Data Sensorium, and how it will be used in the Virtual Art Exhibition system.

3.1. Data Sensorium

Data Sensorium [13] is a Full-scaled and omnidirectional screened technology designed by Iwata, H. of Tsukuba University in 2020 which can project 3D images on the wall and floor using a total of 12 projectors. The proposed system also uses a VR locomotive device called a Torus Treadmill [14] to let the visitors actually walk around the virtual museum with the user's own body. By using these systems in which projecting the museum space and allowing users to walk around using these technologies, it will be possible to view artworks in their actual size surrounding the users and provide a dynamical virtual art experience.

3.2. Artizon Cloud

For the database, we use an art multidatabase system called Artizon cloud as target art data. The system combines multiple databases and provides information about an art museum and artworks which is collected from various archives of artworks and past exhibitions. Currently, the Artizon cloud only handles data of Artizon Museum [15]. By using this multidatabase system, we will be able to display heterogeneous content at the Virtual Art Exhibition system.

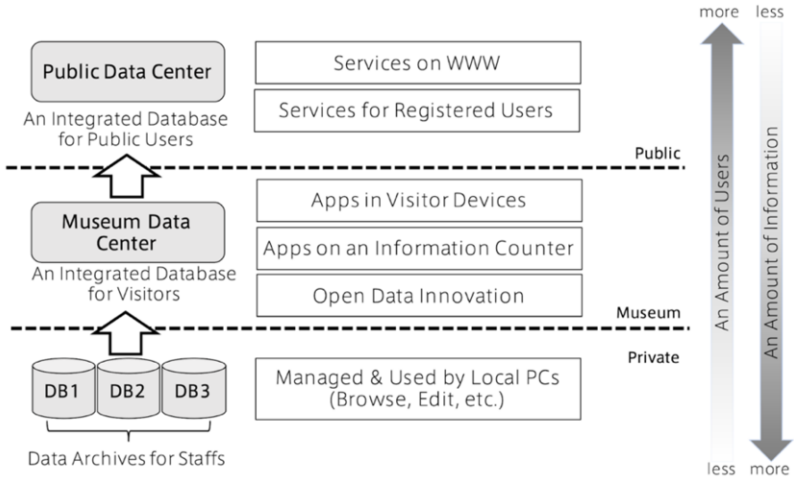

Figure 3. An implementation of *Artizon cloud*

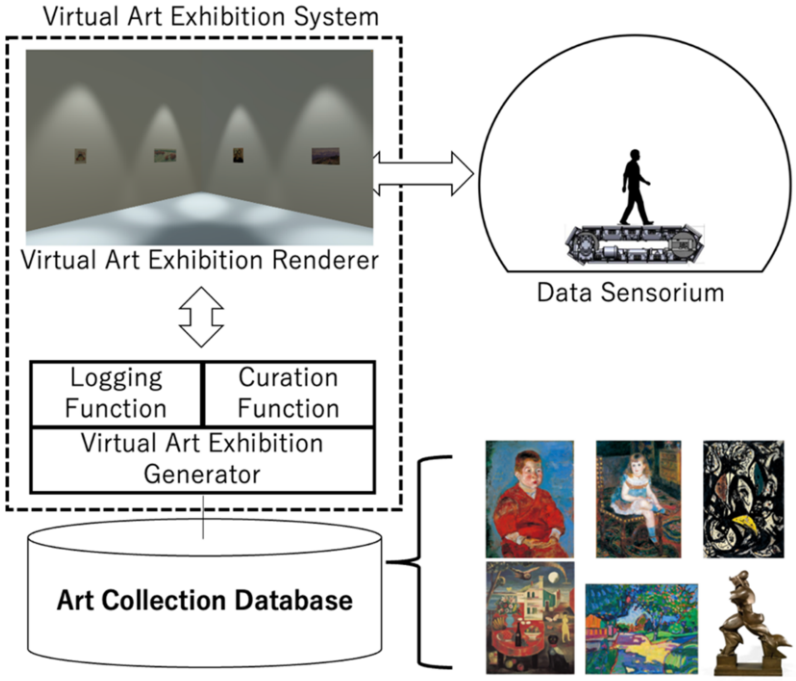

Figure 4. System Structure of the Virtual Exhibition System

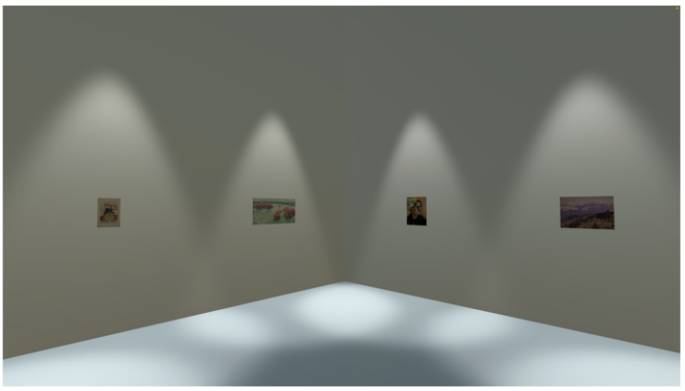

Figure 5. A Screenshot of an exhibition in Virtual Art Exhibition Renderer

4. System structure & Implementation Method

4.1. System Structure

Virtual Art Exhibition System extracts art data from the Art Collection Database, accepts user interaction data obtained from the Data Sensorium, and sends graphics to Data Sensorium (Fig.4). To achieve this, the system consists of the 4 following elements.

4.2. Implementation Method

a) Virtual Art Exhibition Renderer

The first step to set up a virtual museum is to create a room in virtual space (Figure 5). After creating the room, two pictures are placed on each side, in a total of eight artworks in the room (Figure 7). Outside the room (Figure 6), there are two bars which the user can go through. The right one will be re-searching the related artwork based on the most viewed artwork by the user. This means, if the user enters the right bar, the user will be shown a new set of artworks related to the user's intention. The left bar will reset the user's viewed data. The exhibiting artwork's size will be based on the actual size of each artwork when loaded. When the user starts the program, each user is assigned an ID. Based on the ID, the program will calculate and display which picture the user most liked (which most stayed longer). Figure.8 shows a sphere embedded underneath each artwork as a component to record the user's viewing time, and the sphere is set to $2m$ radius and invisible by default so that it will not disturb the exhibition. If the user gets close enough to the artwork, the sphere will count as "IN", and when the user gets away, it will count as "OUT". Timestamps of IN/OUT as well as an artwork identifier are sent to the logging function. The virtual art exhibition renderer is implemented by using a cross-platform game engine, unity [16]. There are many possible approaches to extract users' intention such as monitoring gaze, EEG detection and so on, however we decided to apply the simple metric using sphere to study feasibility of the Virtual Art Exhibition system. More intelligent metrics should be discussed in the future.

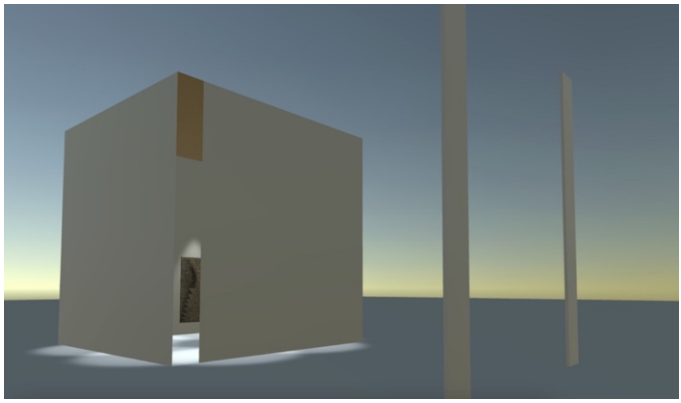

Figure.6 Outside Appearance of Virtual Exhibition Hall

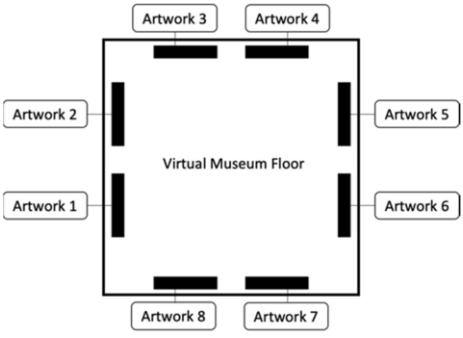

Figure 7. The implementation of *personalized exhibition* (1)

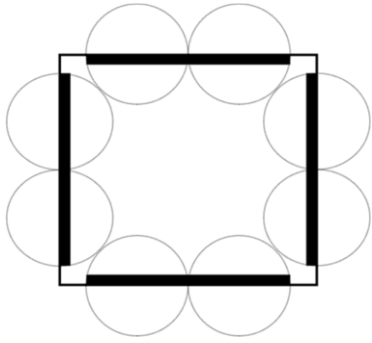

Figure 8. The implementation of *personalized exhibition* (2)

b) Virtual Art Exhibition Generator

Virtual Art Exhibition Generator receives data of the user behavior with the Logging Function, then generates a set of artworks according to users' interest from the Curation Function. The collection data of the Artizon Museum are used as the target data. Since the museum collection is managed by using the Artizon Cloud, a proprietary multi-database system, this system uses the Artizon Cloud API to use the collection data.

c) Logging Function

Logging Function receives IN/OUT timestamps as well as the artwork identifiers and registers these data in the database which is in the Virtual Art Exhibition Generator.

d) Curation Function

The method to calculate the total viewing time per each artwork will be calculated the time the user entered the sphere (OUT) -(minus) the time the user left the sphere (IN). The result time will be defined as the user's staying time in front of the artwork, which means the user has the most "intention" towards. After getting the staying time result, the system will list it in order of the most-stayed and most-less-stayed. After the most-stayed artwork gets extracted, the system will search the next set of related artworks and send the set of the art to the Virtual Art Exhibition Renderer. Once again, related artworks are defined as: artwork that is from the same period, created by the same author and same country to the chosen artwork.

5. Feasibility Study

As a feasible study, we will explain in detail how the changes of the exhibits in the exhibition room experienced by a user using the actual system are presented. Table 1 shows an initial set of artworks that is randomly exhibited. In this example, the user stayed in front of Paul Klee's "garden in POT" for the longest time among other artworks. After the user finishes viewing the exhibition and goes out of the room and re-search the related art works, the next set of artworks is exhibited (Table 2**)**. In this case, it shows that the set of related artworks had been extracted by the same period and same author to the chosen artwork in the first set. For the second exhibition, the user viewed the artwork named "Sunrise" as the longest. Based on this result, the system exhibited the third set of artworks based on the same author and the same country to the chosen artwork.

Overall, through this experiment, it was proven that the Virtual Art Exhibition System had worked successfully and could automatically generate exhibits based on the user's interests and intentions.

Table 1. The searched result of database (1)

Marino MARINI	Rider on an Ochre Ground	1957	Pistoia	00:00:04.054004
Marino MARINI	Waiting	1965	Pistoia	00:00:03.500778
KAWABATA Minoru	Untitled	1993	Tokyo	00:00:08.23219
MASANOBU Masatoshi	Work	1967	Susaki, Kochi	00:00:03.451733
FUKUSHIMA Hideko TAKIGUCHI Shuzo	Displacement Diagram	1974	Tokyo Toyama	00:00:04.386278
Henri MATISSE	Woman with Checked Collar	1937	Le Cateau-Cambresis {now Le Cateau}	00:00:07.014538
Paul KLEE	Garden in POT	1926	Munchenbuchsee, nr Berne	00:00:13.242213
Lee KRASNER	Moontide	1961	New York	00:00:02.550423

Table 2. The searched result of database (2)

Henri MATISSE	Odalisque	**1926**	Le Cateau-Cambresis {now Le Cateau}	00:00:04.319401
KOIDE Narashige	Nude	**1926**	Osaka	00:00:02.767603
Georges ROUAULT	VIII. Satin III (from Flowers of Evil)	**1926**	Paris	00:00:02.566769
Georges ROUAULT	XIII. "Debauchery and death..."(from Flowers of Evil)	**1926**	Paris	00:00:02.552296
YOSHIDA Hiroshi	Sunrise (from Views of Mt. Fuji)	**1926**	Kurume, Fukuoka	00:00:19.112251
Paul KLEE	House in the Water	1930	**Munchenbuchsee, nr Berne**	00:00:03.921128
Paul KLEE	Garden of the Level-Crossing Attendant	1934	**Munchenbuchsee, nr Berne**	00:00:03.653234
Paul KLEE	Jointed Doll Walking	1937	**Munchenbuchsee, nr Berne**	00:00:06.153174

AOKI Shigeru	Bathers	1904	**Kurume, Fukuoka**	00:00:03.785742
AOKI Shigeru	Landscape	1910	**Kurume, Fukuoka**	00:00:02.802216
TAKATA Rikizo	Fountain at the Villa Medici	1972	**Kurume, Fukuoka**	00:00:15.76204
KOGA Harue	Copy from Hans Prinzhorn's Artistry of the Mentally Ill	c. 1930	**Kurume, Fukuoka**	00:00:03.76265
TAKATA Rikizo	Erechtheum in Athens	1938	**Kurume, Fukuoka**	00:00:01.786504
YOSHIDA Hiroshi	Matterhorn, Evening	1925	**Kurume, Fukuoka**	00:00:02.053703
SAKAMOTO Hanjiro	Enokidera Shrine (from Five Views of Tsukushi)	1918	**Kurume, Fukuoka**	00:00:04.18662
SAKAMOTO Hanjiro	Hatsuse Namiko playing Akiyama Sizuko (from Sketch of Players on Stage)	1971	**Kurume, Fukuoka**	00:00:09.803794

6. Conclusion

In this paper, a virtual art museum system is proposed. The virtualization of museums has a lot of advantages, such as creating a chance for users to encounter new, unknown, spectacular artworks and art experience. This benefit is not just for the virtual museum, but also for physical museums as well, which means physical and virtual museums can ultimately reinforce each other. In addition, digitization of artwork has the advantage that artworks can be permanently preserved and passed on to the next generation. As mentioned in the beginning, The goal of the system is to create a realistic, full-scaled virtual museum. Therefore, the proposed virtual museum used the multidatabase system called art collection database (Artizon Cloud) [1] and a walking device Torus Treadmill and Data Sensorium. In this case, we succeeded in generating a museum based on the user's interests and intentions. Through the feasibility study, based on the key word of “Emotional Excitements”, the virtual art museum system provided users an art experience that can only be achieved through virtual technology such as personalized exhibitions. As for the future works, more intelligent and dynamic sensoring metrics to extract precise user’s intention, semantic computation functions for the dynamic curation, storing and sharing functions of user experiences for art communication could be challenged.

Acknowledgement

This research is strongly supported by Asia AI Institute of Musashino University, especially Prof. Hiroo Iwata for introducing Data Sensorium and Prof. Yasushi Kiyoki for coordinating the Art Sensorium Project. The art data are provided by Artizon Museum and Ishibashi Foundation, and a collaborative research relationship with the museum have strengthened this research. We would like to show gratitude to everyone in these organizations.

References

[1] Ishibashi, N.: "Artizon Cloud: A Multidatabase System Architecture for an Art Museum," The 31ST INTERNATIONAL CONFERENCE ON INFORMATION MODELLING AND KNOWLEDGE BASES(EJC2021). (2021)

[2] The Metropolitan Museum of Art: *The Met Collection*, available via WWW, https://www. metmuseum.org/art/collection (2021)

[3] Muse´e du Louvre: *Atlas database of exhibits*, available via WWW, http://cartelen.louvre.fr/ (2021).

[4] Paris Muse´es: *Les collections en ligne des muse´es de la Ville de Paris,* available via WWW, https: //www.parismuseescollections.paris.fr/ (2021).

[5] Muroya, T.: "A Digital Image Archive in a Museum" (In Japanese) available via https://www.jstage.jst.go.jp/article/itej/70/1/70_160/_pdf/-char/ja (2016)

[6] Kovavisaruch, L., Sanpechuda, T., Chinda, K., Kamolvej, P. and Sornlertlamvanich, V.: "Museum Lay- out Evaluation based on Visitor Statistical History," *Asian Journal of Applied Sciences*, Vol.5, No.3, pp.615-622 (2017)

[7] Digitized Thailand: *White Paper*, NECTEC, available via WWW, https://www.facebook.com/ digitizedthailand (2009).

[8] Latham, K.F., J.E. Simmons.: "Foundations of Museum Studies. Evolving Systems of Knowledge" Libraries Unlimited, Santa Barbara, CA. (2014)

[9] SCHWEIBENZ, W.: "The virtual museum: an overview of its origins, concepts, and terminology" (2019).

[10] HASARD: https://wam-hasard.com/

[11] VIRTUAL MUSEUMS: https://virtualmuseums.io/

[12] Mintz, A.: "Media and Museums: A Museum Perspective" (1998)

[13] IWATA, H., SASAKI, S., ISHIBASHI, N., Sornlertlamvanich, V., ENZAKI, Y., KIYOKI, Y.: "Data Sensorium: Spatial Immersive Displays for Atmospheric Sense of Place," The 32ND INTERNATIONAL CONFERENCE ON INFORMATION MODELLING AND KNOWLEDGE BASES(EJC2022). (2022, submitted)

[14] Iwata, H.: The Torus Treadmill: Realizing Locomotion in VEs, IEEE Computer Graphics and Applications; Vol.19 No.6; 1999 pp.30-35

[15] Artizon Museum: https://www.artizon.museum/en/

[16] Unity: https://unity.com/