Tokyo University Digital Museum

Noboru Koshizuka
Information Technology Center/The University Museum, The University of Tokyo
koshizuka@l.u-tokyo.ac.jp

Ken Sakamura
Interfaculty Initiative in Information Studies/The University Museum, The University of Tokyo
sakamura@um.u-tokyo.ac.jp

Abstract

We present our basic philosophy and concept of Tokyo University Digital Museum. The main goal of our activity is to propose new forms of museums of the future in which digital technologies support all kinds of museum activities such as gathering, preserving, researching, exhibiting, and educating about collections. Further, we report our novel digital technologies for the digital museum such as media and human interface technologies for new exhibition styles and data processing technologies for digital archiving of cultural or historical materials. Lastly, we conclude with observation for the museum of the future.

1. Introduction

For around 2,300 years since Ancient Alexander Era, museum has been a facility to restore intellectual and cultural property of human kind and to inherit them to posterity [1]. Generally, museums have two kinds of functions: the primary and the secondary functions. The primary function is to acquire, classify, preserve, and research collections. The second function is the educational activity using collections including exhibitions. Recently, adopting digital technologies, advancing these two major functions of museums, and bringing much higher functions are expected. To accomplish these goals, we have proposed a new style of museum, called “Digital Museum”, which utilizes digital technologies in all of its activities [1].

The digital technologies would be useful for advancing both functions of museum. As for the primary function, digital archive is the most effective method. Whatever the condition of collection preservation in museums is good, the collection will certainly deteriorate with time. The only way to preserve the current conditions of collections is to measure in accurate by means of various scanners and sensors, and to record and store the measurement data in digital formats. By digital technologies, we can make perfect copies of these data easily. If we would make backups of the digital data properly, we can theoretically preserve the records of the current conditions of museum collections without deterioration forever.

The second function, especially museum exhibition, is expected to change drastically by means of multimedia and networking technologies. These technologies include virtual museums built upon hypermedia systems in the Internet such as WWW and, more innovatively, networked 3D virtual environments. These virtual exhibitions supplement the limit of conventional real exhibitions.

Furthermore, the both functions in museums have been contradictory. The objective of preservation is future use, but if those materials are used, a deterioration in the state of preservation is more or less unavoidable. For this problem, the digital technology can provide one solution to improve this situation: utilization of digital data.

As seen above, digital museums have a potential to change the way of museum collection preservation and exhibition in drastic. Furthermore, they will bring a revolution to all museum activities such as curation, management, and business models. We have started “Tokyo University Digital Museum” by applying these concepts to our university museums in the University of Tokyo. The rest of this paper makes a brief overview of the basic concept of the Digital Museum, and the result of our feasibility study in these five years.

2. History and Background

In this section, we briefly present the history and background of Tokyo University Digital Museum. Our university, the University of Tokyo, has established its university museum in 1966. Its main mission was to provide the primary function of museums: collecting, preserving, and studying objects. It consisted of ten sections from humanities to natural sciences, and worked as a center of academic materials preservation. In 1996, our museum has been reorganized, and a new mission, the second function of museums including frequent exhibitions, has been added. Simultaneously, our Tokyo
University Digital Museum project has started as its
leading project. Our mission is to construct a digital
archive of Tokyo University Collection, which consists of
more than six millions of academic materials. Another
mission is to create an innovative museum that fully
utilizes digital technologies. Since 1996, on the basis
of the digital museum concept, we have made six
experimental exhibitions in our university that would cover
various research fields [2,3,4,5,6,7].

3. Concept
Digital Museum is a museum that utilizes digital
technologies in its all activities. This section proposes theive challenging concepts of Digital Museum.

3.1. Museum with digital archives
The first concept of Digital Museum is a digital archive.
There are two backgrounds of the digital archive. First, it
is the only practical way to record and preserve current
states of museum collections without deterioration.
Seconds, it provides a method to solve the well-known
contradictory between preservation and exhibition, by
utilizing the stored data in digital archives. Hence, the
concept of digital archive was born, in which we capture
almost all features of materials, translate them into digital
data, preserve them electronically, and utilize them for
public education or academic researches.

From the past, records have been taken to preserve the
information of materials. Typical examples are paintings,
miniature models, photographs and movies, all of which
are analog information. However, it is unavoidable that
the recording media deteriorate with time. In addition, it is
impossible for copies of analog records to be made at the
same fidelity level as the original records, and in this case,
deterioration in repeated copies is unavoidable.

In contrast, perfect copies of digital data can be made
without any loss of information. Whether the media on
which information is recorded be an optical disk or a
magnetic disk, the information might be lost or mis-
recorded over time. However, by using the digital coding
theory and using redundant information, it is also possible
to discover such errors and then correct them. This draws
the total error rate close to zero. Then, by regularly
renewing data by copying that information itself onto a
new medium, permanent preservation of data becomes
theoretically possible.

On the other hands, preservation and exhibition have
remained to be the major requirements of museums since
ancient times. However, they have been contradictory.
The objective of preservation is future use, but if those
materials are used, deterioration in the state of
preservation is unavoidable. In this case, if it is adequate
enough to obtain only information, not having to take out
actual collections is important in terms of preventing their
deterioration. Digital archive will contribute to this process.
In other words, digital archive promotes the effective use
of actual collections, while at the same time reducing the
necessity of using actual items, thereby protecting the
actual items.

3.2. Three kinds of openness
Here, we present three kinds of openness, which has
not been fully solved until today while it has been
required for museums from the past. We are recognizing
that digital technologies are effective to solving this.

3.2.1. Open cases. The reason museums look up exhibits
in glass cases is not for the benefit of visitors, obviously,
but to protect the collection. Ideally, visitors should be
able to touch the exhibits with their own hands, the better
to understand them. In the case of solid objects such as
pottery, they should be able to feel the shape. In the case
of ancient writings, they should be able to take out and to
leaf it at their own pace. It would be nice to try playing
ancient instruments or striking an old temple bell to hear
its sound. On the contrary, the use of materials must be
restricted to prevent them from being damaged. From a
security standpoint as well, valuable collections need to
be protected from the hand of the public. The Digital
Museum aims to satisfy both needs, that of preserving
collections and that of making them readily available, by
taking advantage of digital technologies.

3.2.2. Open to everyone. A traditional museum offers
many barriers to the disabled, and especially the visually
disabled. Since a museum exists to “put exhibits on view,”
it has very little information to offer the visually disabled.
Even the explanations accompanying exhibits often
consist only of written words on panels. On the other
hand, Japanese explanation becomes a barrier for people
from other countries. Barriers like these that tend to create
a distance between certain people and the exhibits in a
museum can also be overcome by digital technologies.

3.2.3. Open with respect to space and time. The large
museum collection would require an enormous amount of
spaces to put on display all at once, making this
impossible under the present circumstances. Special
exhibits built around a common theme can be held for
limited periods. Once that time is past, the exhibits are no
longer available for viewing. Moreover, an exhibition
cannot be seen by people who do not come to the
museum. For people who cannot be in that place at the
time, this is yet another barrier.

In the Digital Museum concept, the collections can be
seen from anywhere, at any time. Even after a special
exhibition has ended, the exhibited collections can still be seen. Moreover, comprehensive exhibitions can be put combining the resources of other museums as well. This is just the distributed museum concept (See Section 3.5). To overcome the limits of time and place is a part of the aims of the Digital Museum.

3.3. Multimedia presentation

The Digital Museum is not only for looking with the eyes. Going beyond the bounds of conventional museums that put items “on view,” it offers the materials as multimedia, for a wide range of senses including hearing and touching.

For example, in the Digital Museum, information terminals will be located in various places, and explanations will make use of multimedia, from video to audio. In addition to sight and sound, equipment for creating replicas will be introduced to allow tactile exhibitions. Visitors will be able to touch them freely without worrying about damaging the materials (Figure 1). Furthermore, sensors and microchip embedded in the replicas will make it possible for the exhibits themselves to turn a replica into a simulation of the real thing. For example tapping on a plastic replica of a pottery vase will cause it to respond with the same sound as the original.

These uses of multimedia in museum exhibits will not only help ordinary visitors understand the exhibits, but will open the door to people which various kinds of disabilities that up to now have prevented them from enjoying the benefit of museums.

![Figure 1: Old pottery and its replica](image)

3.4. Personalized museum

Personal Museum is an example of supplementing the real with the virtual, in which information will be personalized to meet the characteristics of the visitor.

In many cases in the real world, it is inefficient to respond separately to individuals. For example, if efforts are made to match the expressions on museum panels to the visitors as much as possible, we need to pay attention to the following at the least: Differences in the level of contents for general adults, for experts, and for school children. The accessibility to people with weak eye-sight, color blindness and other physical conditions. Languages used for Japanese visitors and foreign visitors. It is clear that, while a wide range of combinations can be accommodated, museums would become places where real materials could be found within a forest of panels.

In contrast, in the world of computers and information, responding separately to individuals is not a big overhead. If visitors input information about their own characteristics into their PDAs when they first arrive, then it is possible to display text in accordance with those attributes. The information can be displayed in larger fonts if necessary, and it is possible to have the information read out for visually impaired visitors. Moreover, it is possible to identify the visitor, and change the commentary according to the order in which they are viewing exhibits. It should be possible for the museum exhibits to recognize the visitors, and in principle provide a different response for each individual.

3.5. Distributed museum

By connecting virtual museums, we can create the ultimate museum comprising the digital archives of all museums throughout the world on the Internet. This is the concept of a distributed museum. On the other hand, the POS approach of the commercial distribution network states that it is better to input at the place where information is generated, and a similar concept is likely to be introduced into the field of museum collections. For example, whenever a piece of earthenware is found at an excavation site, it is always recorded in a ledger. In addition to this, if an input device such as a 3D scanner is brought in to digitize each piece, the creation of a database would be completed there and then. Reconstruction work could be carried out efficiently in a virtual space using computers, later.

4. Digital Archive Technologies

Digital archive is just the core of Digital Museum, because it is used for both collection preservation and exhibition. The quality of digital archive would decide the quality of Digital Museum. In constructing digital archives, there are many key digital technologies. For example, technologies for databases, huge storages, and data representations are among them. In this section, we focus on data representation technologies, text representations and semantic data format of museums. Compared with other technologies, this is especially important because insufficient data format causes
important information of collections to lose, and will make digital archives useless in the future.

4.1. Data format of digital archives

The basic data format of digital archives is still text. Museum collection includes many writings, such as books, leafs, and inscriptions. Also, every museum collection has attributes represented by texts, such as its name, creators, created date, and its interpretations.

Our museum locates in Japan, and preserves many Asian collections. In handling Asian contents on computers, the main feature is that the character sets used in their texts are very large. For example, Japan, Korea, and China use a common character set called “Kanji”, and the total number of “Kanji” characters is said to be more than 100,000. On the other hands, compared with European languages, “Kanji” presents two other features. First, the forms, and also meanings, of characters had been changing with time. For example, in Japan, and also in China, the standard forms of “Kanji” characters were drastically simplified in these fifty years, so as to decrease hand-writing efforts. Second, the character set is open, so that we can create a new “Kanji” characters. Since the birth of “Kanji”, many characters have newly been created and, conversely, many characters have almost died.

Conventional character codes of current industrial standards and text processing mechanisms built upon the codes are insufficient for these features. In Japan, most computer systems support JIS\(^1\) code or its variations, which contains less than 10,000 characters. Also, it can represent only modern forms of “Kanji” characters. However, museum collections require old forms of characters because, for example, names of materials were represented in the old characters originally. On account of these reasons, current computes cannot show even original names of collections.

For this reason, ideal text processing mechanisms for museums should satisfy the following requirements. First, we should provide open and large character sets. Seconds, because the large character set will contains many different forms of the same characters, so that we need a character dictionaries storing the relationship among the characters. Third, we need not only “Kanji” text processing, but also more general multilingual processing environment.

To accomplish these requirements, we have started a project to develop an ideal text processing mechanism called TRON Multilingual Processing Environment (TRON MPE) [11]. It is a total architecture and consists of character codes (TRON code), text processing mechanisms, requirements for underlying OS specifications (BTRON3 specification), and regulation mechanism to add/delete characters from the TRON code. In present, the TRON MPE supports more than 130,000 characters of many languages all over the world, while its potential capacity is more than 1,000,000 characters (Figure 2).

4.2. Museum TAD

Digital data format of the Digital Museum is required to have diverse attribute description capability while at the same time being general, in a tradeoff relationship. For example, if storing an item of earthenware in the digital archive, related data may include 3D shape data, texture, soil composition analysis data, and written commentary, each of which has its own relationships. Furthermore, data indicating the excavation site from which the earthenware was found, and the state it was in, are required. For ancient documents, it might be necessary to add information of the pronunciation of the time. In this way, it becomes necessary to prepare various types of diverse data formats for each of multiple genres.

On the other hand, to investigate how the ceramic ware

\(^1\) JIS is an abbreviation of Japan Industrial Standards.
affected those of later years, and how they affected other items from other areas, the data format of the digital archives should not be diverse for each genre, but be standardized. In addition, for our distributed museum concept, this standardization is strongly required. This standardization must define properly the data structure (syntax) and its meaning (semantics) so that the computer can understand and process the data. Without this feature, it is impossible to carry out an integrated search extending across multiple museum databases.

To answer this need, we are developing an attribute description data format for the museum that we refer to as Museum TAD\(^2\). The TRON code referred in Section 4.1 is defined in this data format framework. In the Museum TAD format, to accomplish the two requirements of diversity and generality, we have adopted an object-oriented language called PCO (Portable Compound Object) [13]. By using the object-oriented framework, we can create diverse data formats efficiently by defining subclasses from the base class. On the other hand, we can accomplish generality by using its inheritance mechanisms. In the future, if the Museum TAD will be succeeded, we can realize a distributed museum in which museums in the world are linked with one another.

5. Digital Exhibition Technologies

5.1. Museum as information provider

This section describes exhibition technologies of Digital Museum. Digital Museum incorporates with not only virtual galleries but also real galleries. As for digital virtual exhibitions, we have built a virtual museum upon WWW system on the Internet (Figure 3). Further, we have build a new type of virtual museums consisting of a cooperative virtual environment called as MMMUD (Multi-Media Multi-User Dungeon). As for real exhibitions, we have proposed several augmented-reality technologies to enhance real exhibitions.

5.2. Virtual exhibition (MMMUD)

MMMUD (Multi-Media Multi-User Dungeon) system aims to build virtual museums [8,9,10]. Enormous numbers of academic materials of museums are digitized and stored as digital archive, and they are exhibited in the MMMUD virtual museums. The virtual environment of the MMMUD is managed by server systems. In order to join with the virtual environment, users run a MMMUD browser on their terminal computers and the browsers are connected to the server system via network. When a browser is connected to the server system, an agent of the user in the virtual environment, called an avatar, is created. The MMMUD browser renders images of the virtual environment from the view of its avatar. Users can control their avatars and can explore the virtual environment.

Features of exhibitions in the MMMUD virtual museums are as follows. First, different from the real world, we can acquire as large exhibition spaces as we want to use. Museums collect many academic materials, however, we can see only a part of the materials due to the limited exhibition spaces. On the other hand, in the virtual museums, we can see many academic materials that cannot be shown in the real museums. This is because the virtual environment can provide almost infinite exhibition spaces.

Another feature is that the virtual museums are used as not only database browser of museum’s collections but also used as communication spaces for users. Recently, there are many web-based virtual museums, in which we can see various collections of the museum, but we cannot talk about the exhibitions with others. On the contrary, the MMMUD allows users to communicate with each other. The MMMUD browsers render not only images of the rooms and exhibits in the virtual environment but also images of other avatars. You can see motions of other avatars, and which exhibits other users are interested in.

This information is important for users to decide which exhibit to see next. The MMMUD system also supports other types of communications among visitors with real-time voice chatting and multi-user tools. With these mechanisms, you can be explained about exhibits by other visitors, and can talk about the exhibit with them.

The MMMUD virtual museum displays collections in the same way as real museums. Users can view explanations of materials in front of their avatars and extract various multimedia data by using the following tools.

Explanation tool: Explanation tool is a tool for reading explanation texts, which will be displayed as hypertext documents containing links to other texts or other collections. Moreover, this tool can read the explanation text by using speech sound (Figure 5).

Magnifying glass tool: Usually, digital archives contain much higher resolution images than the resolution of usual computer displays. Thus, to see image data in the digital archive in its full resolution, we provide a virtual tool to magnify the image data on our display.

Rotation tool: Rotation tool is a tool to observe 3D geometric data created by 3D scanners. By using this tool, users can rotate and magnify materials represented in the 3D geometric data (Figure 7).

\( ^2 \) TAD is an abbreviation for TRON Application Data-bus, and is the name of a data format standardized across applications of TRON - the computer framework studied and developed by us.
Special tool to visualize the distribution of seismic centers: This tool is a very special tool to visualize the spatial, time, and scale distributions of seismic centers. For instance, this tool provides a command to change time scales. This can enable users to view the spatial distribution of seismic centers of earthquakes occurred during any period. In the same way as the rotation tool, this can rotate and magnify the 3D maps of seismic centers.

Cooperation tool: Cooperation tool is a tool to observe other user's behavior using tools. When users uses the cooperation tool, they can see the observed users' screens. The observing user's screen will change in real-time according to the actions of the observed users. The observing and observed users can talk with each other while they use the same tool. This mechanism supports users to exchange information or to discuss about materials.

In real museums, visitors can hear explanation of materials by curators and participate museum guide tours. The MMMUD virtual museum can also provide this function, called **video guide tour function**. This function shows a special avatar in the form of human video images. This special avatar gives users guidance and explanation of museum exhibits. This special avatar, called **video avatar**, has a function to move in the virtual environment and, moreover, other usual users participating the video guide tour follow the video avatar automatically [10].

5.3. Real exhibition (augmented-reality)

This section shows several augmented-reality (AR) museum exhibition systems [12].

5.3.1. PDMA. PDMA (Personal Digital Museum Assistant) is an information system in which a PDA screen displays explanatory information by holding the PDA over exhibition objects (Figure 8). In this system, an IrDA transmitter is set nearby an exhibit object that always sends the object ID. The PDA contains an IrDA receiver and shows information according to the received ID. Using PDMA, users can select information presentation
formats according to users’ needs. For example, users can select normal displays, large character displays for the elders and the low vision, easy information especially for kids, and English display for foreigners.

5.3.2. Museum AR information system. Museum AR information system gives visitors exhibition information overlaid upon objects through a see-through HMD equipped with a small CCD camera that captures object IDs. This system is a combination of the bar code method and the overlaid display using an HMD. This system enables visitors to obtain overlaid information by only turning their eyes onto the objects that they are interested in (Figure 9).

5.3.3. Point-it. Point-it is a novel museum information system using laser-pointing method and speech sound output. Seeing exhibition, visitors bring laser pointers and PDAs with speech output function (Figure 10). Walking in a gallery, they approach to a display case, and then the PDA firstly speak overall explanation of the exhibit automatically. When they want to know more precise information about each object, they only have to point its title plate by their laser pointers. We have designed this system by simulating an expositor always accompanying beside visitors. When they are approaching to a new display corner, the expositor talks about the theme of the corner. They standing at the corner, visitors may ask the expositor by pointing their fingers, “What’s that?” Then, he/she gives more precise information for each object.

5.3.4. Real-world bookmarking. In the museum, visitors often take memos about explanations of displayed objects. In case of conventional WWW browsers, this activity is strongly supported by the bookmarking function. Thus, we propose Real-World Bookmarking System that enables museum visitors to store pointers of exhibition objects for latter references through the Internet. Visitors bring an RFID card that conveys visitor’s information (Figure 11-(1)). An input device such as a switch and an RFID reader are put in front of exhibition objects (Figure 11-(2)). When they want to store their information, they first put their RFID card on the reader to let the system recognize the visitors’ IDs, then put a bookmarking button to record the pair data of a visitor ID and object ID (Figure 11-(3)). By the operation, the
museum bookmark server receives and stores the data for further queries from their homes via the Internet. In our current pilot implementation, a personal computer is used for the unit working as a bookmarking switch and an RFID card reader controller. The PC shows thumbnail images of objects displayed in the display case, and visitors can select which objects they record as bookmarks (Figure 11-(4)).

(1) Visitors information card  (2) Card I/F unit  
(3) A visitor bookmarking  (4) Sample screen in bookmarking  

Figure 11: Real-World Bookmarking

6. Conclusion

This paper briefly introduces the basic concept and key technologies of Tokyo University Digital Museum. The main goal of our activity is to propose new forms of museums of the future in which digital technologies support all kinds of museum activities such as gathering, preserving, researching, exhibiting, and educating about collections. Further, this paper has reported our novel digital technologies for the digital museum such as media and human interface technologies for new exhibition styles and data processing technologies for digital archiving of cultural or historical materials.

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