Chapter 10

PERSONALIZING THE MUSEUM EXHIBITIONS:
Arrangement Issues

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Abstract In this paper, we discuss personalization of museum exhibitions, which makes exhibitions easier to understand and thus the visitor's experience richer, focusing on arrangement among other aspects: object, information, and structure. Arrangement personalization means to change the order of objects in an exhibition for each visitor according to the visitor's interest. We introduce the preliminary applications, Virtual Nara City and Virtual Rekihaku, that personalize arrangement differently with the help of the Mediator system. Virtual Nara City shows how a tour course can be personalized while Virtual Rekihaku illustrates a personal gallery customized for each individual visitor.

Key words Museum exhibition, Virtual museum, Personalization, Personal gallery, Course recommendation.

1 INTRODUCTION

Museums are places for the general public to see, learn about and enjoy cultural heritage, humankind, nature, and so on. Museums are also places for experts like curators and museum staff to give structured expertise on museums' collections, the joy of learning and new experience to the general public. If they overcome the limitations that prevent visitors and experts from exchanging their intentions, interests, and expectations of museum exhibitions, museums can become a new environment for knowledge sharing between visitors and experts, and then among the people throughout. We have proposed the Meta-Museum as a new concept for a such knowledge sharing environment [1], [2].

Among the problems that prevent traditional museums from functioning as such an environment is limited access. Museums are usually open during the daytime on business days and most of them are located far from where potential visitors live. This restricts people from visiting museums. Even when people can visit a museum, there is another obstacle, i.e., the space limitation. The physical space in which museums can display their collections along with written

explanations is limited and in most cases museums have more items in their collections than they can display. Consequently, visitors can only access a limited number of objects (artifacts, paintings, specimens, and so on) and a limited amount of expertise through reading the explanations at a museum exhibition.

The most promising technology to overcome these problems may be virtual museums. Millions of web pages can be found on the Internet. Virtual museums on the net free people from limits to access. Museum staff can put as many as items they want on their virtual museums. The more web pages online, the more objects and information are available to people. On the other hand, people can visit a virtual museum anytime and from anywhere and see their favorite things long enough without being anxious about other visitors crowding around them. In addition, today's computer technologies have made the virtual museums more than just a collection of texts and still images of objects. Visitors can feel as if they are visiting a real museum when they interact with virtual galleries created by, for example, QuickTime VR [3].

The difference between virtual museums and traditional museums is whether they are digital or not. Virtual museums have objects and information in digital form that can be distributed via the Internet as far as the network can reach while traditional museums have real objects that are fixed to a certain physical space. This difference makes it possible for virtual museums to overcome the access problem.

Virtual museums and traditional museums, however, have a similarity in how they exhibit their collections, and both of them still have the same major problem, although the virtual museums seem to be successful in overcoming the disadvantages of traditional museums. This problem is that visitors do not always understand exhibitions thoroughly nor wholly enjoy them. They sometime miss the points that curators expect them to understand. In other words, visitors and curators cannot exchange their interests and knowledge sufficiently and thus museums cannot function as knowledge sharing environments.

In traditional museums, an exhibition is the main activity to show collections. Usually a museum exhibition has a main theme that is broken down into sub-themes. Objects and related information are grouped according to the sub-themes and then placed in galleries. No matter how widely diverse visitors are in their backgrounds, interest, nationalities, ages, and purposes to visit, a museum exhibition is presented in only one form. Museums never display different objects in different orders or provide different explanations in different modes for a certain exhibition.

This is also the case in virtual museums. In spite of the possibilities for becoming totally new and different from traditional museums, thanks to the freedom from physical restrictions and advanced computer technologies available, virtual museums adhere to the exhibition style of the traditional museums. Even when the exhibitions are truly "virtual" in the sense that they have no original counterpart in physical space and thus do not need to emulate an original exhibition to convey a real feeling and/or accurate information, virtual museums put the same virtual exhibitions online to the wide variety of visitors.

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The reason why visitors cannot understand or enjoy exhibitions thoroughly is due to the problem described above, i.e., "one exhibition for all kind of visitors." On the other hand, if museum exhibitions are personalized to each visitor based on his/her interests and/or knowledge level, they can give better understanding and a richer experience to the visitor. Accordingly, personalization of museum exhibitions is very important.

Before discussing personalization, we need to take a closer look at a museum exhibition and how it is organized. Curators selects a limited number of *objects* from the entire collection according to the exhibition's theme and then prepare *information* related to the objects, usually as labels or sometimes as still images or video. These objects are then related to each other so that they have semantic and usually hierarchical *structure*. Note that the hierarchical structure of the exhibition's theme exists only in the curator's mind at the moment. Finally, the selected objects are *arranged* into galleries composing a unit that corresponds to the sub-theme so that the hierarchical structure is well mapped to the physical space. In short, the components of a museum exhibition are not only *objects* and *information* but also *structure* and *arrangement*.

Objects and information are easily recognized by visitors, but structure is not. Once the semantic structure is mapped to the physical layout, i.e., floors, galleries, showcases and so on, visitors must infer the curators' thoughts. Moreover, it becomes difficult for visitors to see the objects from different points of view since there exist a stern arrangement of objects, which implies that objects located near each other have a stronger relationship. Therefore, personalization should be done for structure and arrangement as well as objects and information.

Previous studies on personalization, mainly done in the area of traditional museums, have dealt with objects and information. Object-based personalization means to select the objects from the exhibition for each visitor. For example, the "Micro Galley" system [4] at the National Gallery in London selects the pictures from the collection when a visitor specifies the name of a painter and shows them, along with a map to their location, on a computer display. On the other hand, information-based personalization means changing the presentation mode of information; whether it is written text or voice message, whether it is in English or in Japanese, whether it is concise or detailed [5]. This personalization is usually realized with handheld computers.

As for structure, we have proposed a novel personalizing method based on the semantic relationship among objects [6], [7]. The mediating agent first visualizes and shows a visitor, as a two-dimensional space, the semantic structure of an exhibition that is a systematic representation of the expert knowledge of one or several curators. Then, the mediating agent acquires the interests of the visitor and uses the information to help restructure the original exhibition, i.e., the agents produce a new two-dimensional space representing the semantic relation among objects from the visitor's point of view. Finally, the mediating agent creates one more two-dimensional space where the semantic relationship of objects is structured based on the visitor's interests as

well as the curators' knowledge. Object-based personalization may make a museum exhibition more difficult rather than easier to understand since the objects are selected intermittently and break the hierarchical structure. On the contrary, structure-based personalization takes full advantage of the expert knowledge that the original exhibition holds.

The last component to be personalized is the arrangement. Unfortunately, little attention has been paid to arrangement in terms of personalization. Arrangement personalization is, however, important and more feasible in virtual museums as we will discuss later.

In this paper, we discuss the personalization of arrangement in a museum exhibition. Section 2 first summarizes relates works. Section 3 then introduces how the Mediator system [8], the new version of the mediating agents, personalizes the semantic structure. Section 4 describes arrangement personalization and gives two illustrative applications called *Virtual Nara City* and *Virtual Rekihaku*. These two systems employ Mediator as a recommendation system. Finally, Section 5 concludes the paper.

2 RELATED WORKS

There have already been so many virtual museums and the number is growing more and more thanks to the Internet and other digital technologies. There has also been a strong and growing demand for such new technologies in traditional museums so that they can establish themselves as more comprehensive institutions regarding cultural heritages. This situation has produced a huge amount of research and reports related to those computer technologies applied in or applicable to museums.

The objective of this section is not to provide an exhaustive survey on such research but to give insight into the complicated circumstance that is projecting the diverse demand and motivation of those who are involved in this area. We hence focus on topics of personalization and discuss this according to the four categories introduced in Section 1, i.e. object, information, structure, and arrangement.

Object-based personalization is very similar to search engines on the Web because it selects objects that match a specified one or more keywords from the entire collection. As mentioned in Section 1, the Micro Gallery [4] is a good example.

Most of the research and efforts have been concentrated on information-based personalization that makes wider choices available to visitors to access information depending on their interest or favour. This is because: firstly, there have been strong demands for easily and widely accessible information, and secondly, the small and high-performance devices providing personal information are increasingly available.

Voice guidance systems have already been in practical use in many museums, though the used devices and extent of visitor's interaction are quite different. For example, Schönbrunn Palace in Vienna has an audioguide that a

visitor brings along during the tour; a visitor presses a button to hear voice narration whenever entering a room. The guide system installed in the Musica Imperialis in Vienna plays a short musical phrase corresponding to the musical score the visitor is currently looking at.

On the contrary, the permanent use of museum guidance systems that employ small computers to visually provide information has not been so popular. The Minpaku Electronic Guide [5] is a good example of such systems. A visitor with a small computer can select the preferred language from eight choices and can receive information represented in either text, still images, movies, or audio automatically when standing in front of an object. Of course, a great deal of research and temporal use for testing is ongoing. Among them, we point out a few such as C-MAP [9] and Digital Museum 2000 [10] for the reader unfamiliar with this area. In particular, Digital Museum 2000 held by Tokyo University Digital Museum as a temporal exhibition is remarkable, where the originators exploited augmented reality for presentations. Visitors can see real objects and related information at the same time through the HMD (Head Mounted Display) [10].

One distinguishable approach to information-based personalization is the dynamic production of descriptions per visitor. ILEX [11] is based on natural language generation and a template technique, while HyperAudio [12] is based on the reuse of existing material called Macronodes consisting of small pieces of text connected by directed graphs.

In comparison with the object-based personalization, research on structure-based personalization has progressed slowly. Revealing Things [13], an online exhibition by Smithsonian Institute, provides the Maplet where linked titles appear so that visitors can see the semantic relation among the titles focusing on the selected titles. C-MAP [9], a context-aware mobile guidance system, provides information through a handheld computer where the Semantic Map shows the relation among objects based on keywords. If the visitor selects different keyword(s), he/she gets different views in the Semantic Map. However, we think these two attempts personalize not the semantic structure itself but its view.

Finally, to our knowledge, it seems that little attention has been paid to arrangement. One indirect approach is shown in CICERO [14], a system that assists in planning personalized tour courses. CICERO calculates and prints the path to be followed by the visitor along with the objects that match the visitor's interest. We will discuss a course recommendation for an individual visitor, which is thought to be a quasi arrangement personalization, later in Section 4.1.

3 THE MEDIATOR SYSTEM

In this section, we briefly mention about the Mediator system that personalizes not arrangement but structure of an exhibition because we utilize Mediator as a recommendation system to personalize arrangement.

The goal of the Mediator system is to personalize the semantic structure of an exhibition based on a visitor's interests while exploiting the knowledge of curators. We assume that curators' knowledge is represented in explanations written on labels attached to objects, on posters hung on the walls, and so on.

The most significant feature of Mediator is its visual representation of the semantic structure that cannot be seen directly. Visitors can interact with the visual representation, i.e., they can move icons or show text, to check how the semantic structure changes as the point of view changes. The visual representation is also an interface for Mediator to acquire the visitor's interests, which are needed for the personalization process.

To visualize the semantic relationship among objects in two-dimensional spaces, Mediator employs the principal component analysis method[1]. The explanatory text given to each object is regarded as an item and the keywords extracted from the text are regarded as attributes. Since it is usually a high-dimensional space spanned by the keywords, Mediator uses the two most principals for x and y axes to project the original space onto a two-dimensional space. Simply speaking, more closely related objects are arranged together in a two-dimensional space as more keywords co-occur in the objects.

The Mediator system creates three different two-dimensional spaces: Exhibition Space, Interest Space and Personalized Space in this order. The Exhibition Space represents the semantic structure of the original exhibition and thus we can assume that the space represents the structure of the curators' knowledge. On the other hand, the Interest Space represents the semantic structure of objects made by the system after a visitor specifies the objects of interest, which implies that the space represents the exhibition reorganized based on the visitor's point of view. Finally, Mediator creates the Personalized Space, which can be regarded as a representation of a fusion of the interests of the visitors and the knowledge of the curators.

Figure 1 shows a screen snapshot of Mediator. Highlighted icons indicate that they are selected by a user. Note that if the user selects different icons the Interest Space and the Personalized Space change, though the Exhibition Space remains constant.

The difference among these three spaces is determined by which keywords the Mediator system uses to calculate the bases of the spaces and which objects are allocated in the spaces. When creating the Exhibition Space, Mediator uses all of the keywords and allocates all of the objects included in the original exhibition.

After a visitor selects some icons of interest displayed in the Exhibition Space, which correspond to objects, Mediator creates the Interest Space by

calculating the bases with the keywords included in the selected objects and then allocates the objects in the space. In addition, Mediator allocates the objects having the keywords that it used in the previous step. Objects that do not have the keywords are discarded and appear in neither the Personalized Space nor the Interest Space.

The Personalized Space is created just after creating the Interest Space without the visitor's intervention. The Mediator system calculates the base using all of the keywords gathering from all of the objects in the Interest Space and then allocates all of the objects.

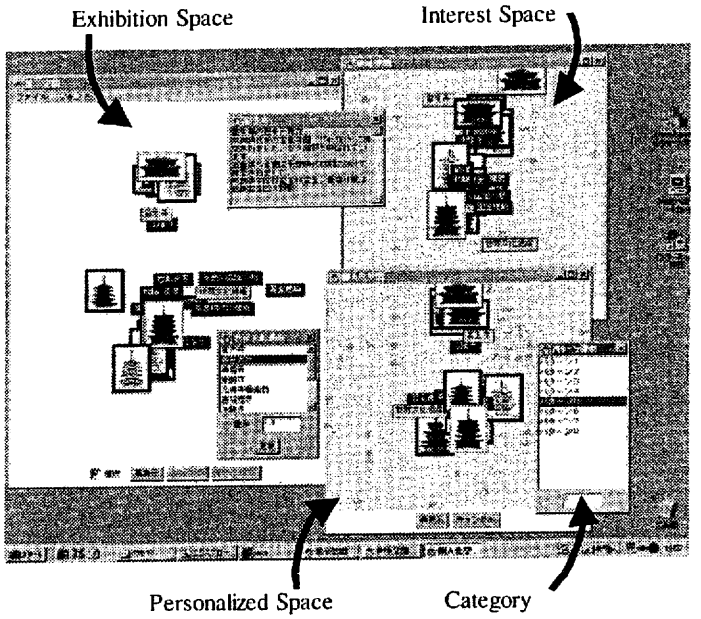


Figure 1: Two-dimensional projection of the semantic relationship among objects included in an exhibition. Three spaces have different x and y axes so that they can reflect the different viewpoint of curator, visitor, and Mediator in the Exhibition Space, Interest Space, and Personalized Space, respectively.

Assume that a museum exhibition has five objects and their keywords are given weight as shown in Figure 2. When creating the Exhibition Space, all objects and all keywords are used (Figure 2 (a)). Suppose a visitor selects two objects, o_1 and o_2, in the Exhibition Space. The keywords k_1, k_2, k_3, and k_4 are used to span the Interest Space, and objects o_1 and o_2 are arranged in the space and then o_3 and o_4 are also placed. However, object o_5 is discarded because it does not have any of the keywords k_1, k_2, k_3, or k_4 (Figure 2 (b)). Since object o_5 has already been discarded, the five keywords included in the rest of the objects are used to span the Personalized Space, and objects o_1, o_2, o_3, and o_4 are arranged in the space (Figure 2 (c)).

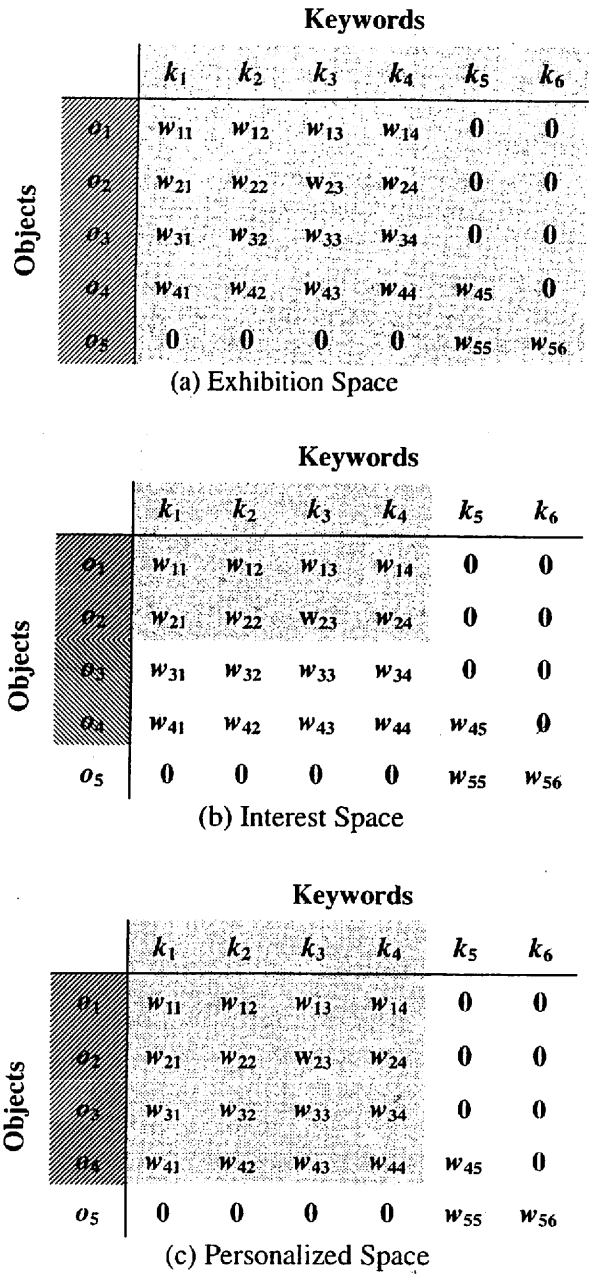


Figure 2: Those objects that are arranged in the space are identical to the objects that are used to calculate the base of the space in the Exhibition Space and the Personalized Space. On the other hand. in the Interest Space, only the objects selected by a user are used to calculate the base while additional objects that share the keywords with the selected objects are also arranged in the space.

Another feature is related to the capability of recommendation, which is required by arrangement personalization. As mentioned before, the closer the objects are placed together, the stronger the relationship they have. Mediator categorizes object pairs into eight categories based on the transition pattern of the distance in each space. These categories are then used to recommend objects, assuming that each category can be interpreted as shown in Table 1.

Table 1. Categorization of object pairs based on the distance between the two objects and the interpretation.

Category No.	Exhibition Space	Interest Space	Personalized Space	Interpretation
1	near	near	near	No discovery
2	near	near	far	Discovery for both
3	near	far	near	Diccovery for visitor
4	near	far	far	No effect on different opinions
5	far	near	near	Discovery for curator
6	far	near	far	No effect on different opinions
7	far	far	near	Discovery for both
8	far	far	far	No discovery

Although the object-based personalization selects objects that exactly match the visitor's request, Mediator selects objects according to the specified category, and thus the recommended objects do not always exactly match the objects selected by the visitor in Exhibition Space.

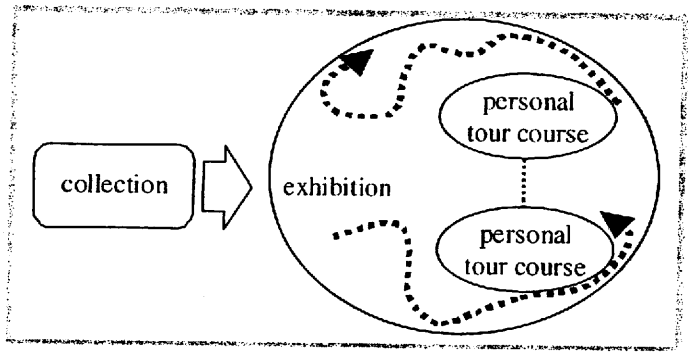
4 PERSONALIZATION OF ARRANGEMENT

First of all, we should discuss which museums are the targets of this study. Since virtual museums have normally been thought to be rivals of traditional museums, research on the personalization issue have been done separately and have focused only on either domain. For example, research on information-based personalization using palm-top computers does not mention about its possibility in virtual museums. We think the mechanism should requires further investigation, even though the physical system is not directly incorporated into the virtual space.

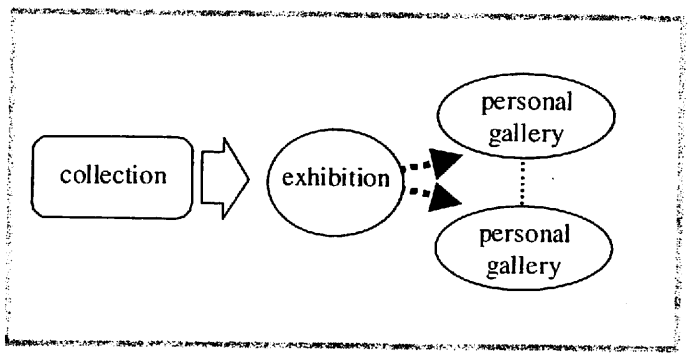
On the other hand, our study covers both traditional and virtual museums since we think they complement each other and their tight binding is essential to realize Meta-Museum. Meta-museum is not merely a museum of museum as it may be inferred from the name but a media fusion of traditional museums and virtual museums regarding its formation, the interdisciplinary fusion of those museums regarding the theme of an exhibition, and the dynamic fusion of the inside and outside of the museum buildings regarding the real-time exhibition or report of events happening in the world.

Consequently, we discuss three possibilities of arrangement personalization that can be applied to both or either traditional and virtual museums: Personal

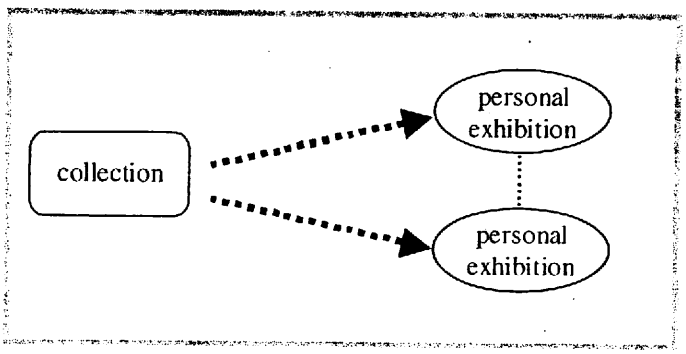
Tour Course, Personal Gallery, and Personal Exhibition. The difference among them is depicted in Figure 3.



(a) Personal Tour Course



(b) Personal Gallery



(c) Personal Exhibition

Figure 3: Three different approaches for arrangement personalization. There is an exhibition shared by visitors in the first two approaches though the last one has no common exhibition. Note that the first two approaches can also use the collection directly to produce a personal tour course or a personal gallery if needed.

4.1 Personal Tour Course

In traditional museums, it is almost impossible to change the whole arrangement of the exhibition for each visitor. Alternatively, quasi arrangement personalization, i.e. a short guided tour or recommended tour shown in a booklet that covers famous and valuable objects has been provided. This is, however, not personalization on the basis of each visitor's interest.

Mediator plays a central role in recommending a personal tour course to a visitor based on his/her interest. As mentioned in Section 3, Mediator classifies object pairs into eight categories as a result of mediation between a visitor's interest and the curators' knowledge. If the visitor selects one category, Mediator sends object IDs to another system that needs some criteria for recommendation.

As an example of tour course recommendation for an individual visitor, we have built an integrated system for exploring virtual Nara city using Mediator and VisTA-walk [17]. VisTA-walk is a walk-through system for virtual space projected onto a 170-inch screen that gives more realistic sensation than desktop displays. The outstanding feature of the system is that a user can explore the virtual space by his/her gesture and movement due to the gesture recognition system, which does not require the user to wear any devices.

Virtual Nara City is an application sites developed with the VisTA-walk system to explore Nara and visit temples recently registered as World Heritage. We modelled a 40-km^2 land area that covers Nara City and approximately 10 temples. Each temple and its architectural aspect have several pieces of information such as its origin, explanation of building techniques, history and so on. A user can see such information simply by raising his/her hand and selecting a temple or a certain portion as well as he/she can walk around in the virtual space by his/her steps forward, backward, left, and right. Having this capability, Virtual Nara City can be regarded as a virtual museum.

Needless to say, the user can enjoy Virtual Nara City by himself/herself without any help while he/she freely explores it and gets information about interesting objects. However, once he/she consults Mediator, he/she can enjoy the virtual museum from another viewpoint. If the user selects several icons in the Exhibition Space, Mediator immediately creates the Interest Space and Personalized Space and shows eight categories with the number of objects in the Category window as shown in Figure 1. The user can reset the selection and select other icons again if needed. Finally, Mediator sends object IDs included in the category the user specified to VisTA-walk so that VisTA-walk can recommend personal tour courses to the user. This process is illustrated in Figure 4.

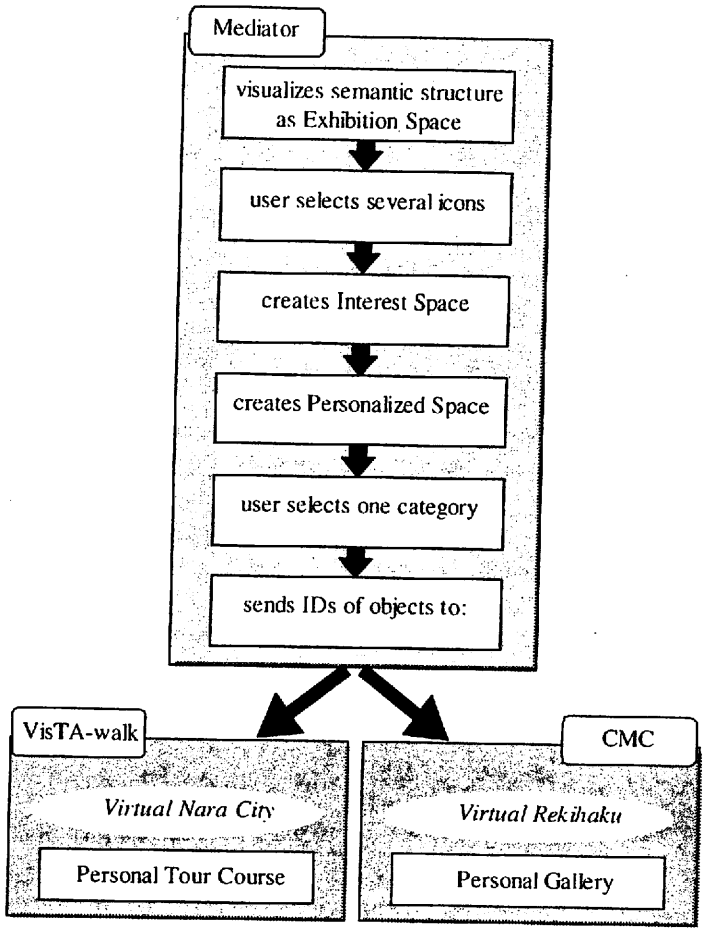


Figure 4: Personalization process by Mediator, VisTA-walk, and CMC. Mediator is used as a recommendation system. VisTA-walk and CMC are used to make the demonstrative applications of the arrangement personalization.

One way to recommend a personal tour course in virtual space is a guided tour by an agent such as we introduced in the first application of VisTA-walk [18]. The multi-modal guide agent can give suggestions by gesture and voices, by which the visitor learns which way to follow and which objects to see and select for more information.

The alternative is to exploit the main advantage of virtual spaces, which is that there is no limitation of movement; a visitor can freely move horizontally and vertically in the three-dimensional space and view the world from different perspective or can move very fast no matter how large the virtual space is. If a system automatically provides such a view along with the personal tour course, it will be very helpful for the user to understand the virtual space.

Based on the above consideration, we designed the function of personal tour course recommendation. VisTA-walk automatically begins the tour when it receives object IDs from Mediator and shows the explanation while visiting the temples. Figure 5 shows an example of recommending a personal tour course in autopilot mode in VisTA-walk with the help of Mediator. Note that after the automatic tour finishes, the visitor can freely explore Virtual Nara City again.

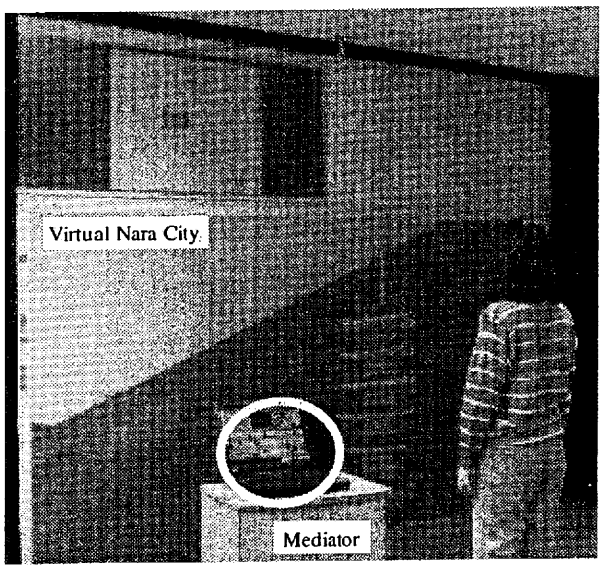


Figure 5: User looking at a temple in Virtual Nara City along the personal tour course recommended by Mediator.

Although Virtual Nara City is a virtual museum and not a traditional museum, we think this approach can be easily applied to a traditional museum if we use hand-held computers as already in use in some museums. For example, a visitor first consults Mediator installed at the entrance and then receives object IDs with his/her hand-held computer so that the hand-held computer indicates the next destination during the visit.

4.2 Personal Gallery

If we consider only virtual museums, another scenario becomes apparent. The second possibility of arrangement personalization is creating a personal gallery for each visitor. Rearrangement of display is much easier in a virtual museum than in a traditional museum. In spite of that, existing virtual museums do not take full advantage of it. Our approach is to create a personal gallery where only the objects recommended by the Mediator are displayed while the original virtual museum and its exhibition are also preserved to be explored at any time.

The main advantage of this approach is that the visitor can come and go between the personal gallery and the original exhibition at any time. The visitor can easily compare the exhibit of his/her personal gallery with the original one, which would help him/her notice the difference and trigger a careful look at the personalized and original exhibitions.

Another advantage is that visitors could easily know, and compare their own with other visitors' reactions to the original exhibition if there is an interface that allows multi-users to access the virtual museum at the same time and visit each other's personal gallery. This situation may be equivalent to a real visit to a museum in a group, when people talk to each other about objects.

To demonstrate the potential of the personal gallery, we have set up an application called *Virtual Rekihaku*[2], by integrating CMC (Comprehensive Museum Creator) [19] and Mediator. Personalization process by these two systems is depicted in Figure 4.

CMC is a system for creating virtual museums and exploring them, developed with InventTcl [20], [21] which is a 3D graphics programming environment based on Open Inventor and Tcl/Tk. The walk-through viewer and an auxiliary viewer allow users to explore three-dimensional virtual museums and see the explanation of the galley or the objects by clicking as shown in Figure 6. On the other hand, the layout editor provides functions for designing a floor plan of museum, e.g. the number of galleries, the size of each gallery, wall and showcase position, editing of the explanation text for objects, and mapping of the texture to the objects (the left part, bottom-right, and top-right part of the layout editor shown in Figure 7).

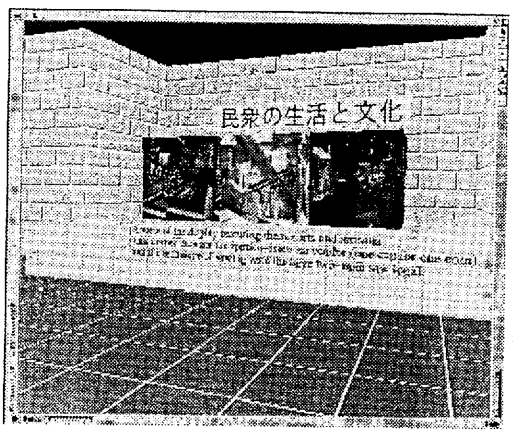


Figure 6: Walk-through viewer showing one of the galleries in Virtual Rekihaku. Explanation text of the object in the middle is shown under the object.

[2] Rekihaku is a nickname of the National Museum of Japanese History in Chiba, Japan.

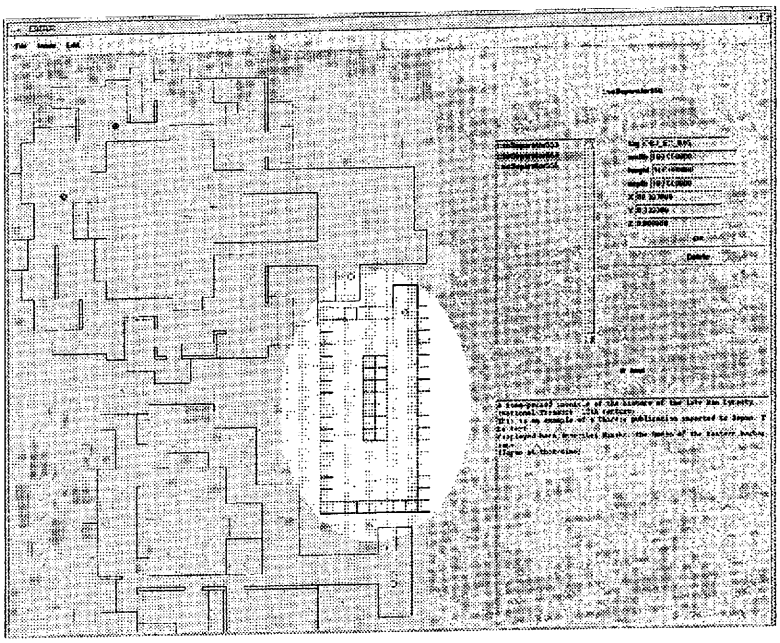


Figure 7: Layout editor showing the floor plan of Virtual Rekihaku with the personal gallery (highlighted).

Note that the personal gallery should also be designed in the editor beforehand, by determining the position and maximum size of the gallery, the maximum number of objects to display, and the layout of the wall and showcase. The size of the personal gallery is not fixed and will be scaled down according to the number of the objects when CMC receives the IDs of the recommended objects from Mediator. Figure 7 shows the floor plan of Virtual Rekihaku where the layout of a personal gallery appears in the middle right of the designing part while the original floor plan of Rekihaku is also incorporated[3]. In this case, the personal gallery can display a maximum of sixty objects.

Also note that the personal gallery does not appear at first when a visitor access to the Virtual Rekihaku as shown in Figure 8 (left) but appears after the visitor consults Mediator as shown in Figure 8 (right).

[3] We obtained the floor map and the information of the exhibition from the museum's web site. Though the actual floor plan has two floors, we modified it to fit into a single layer.

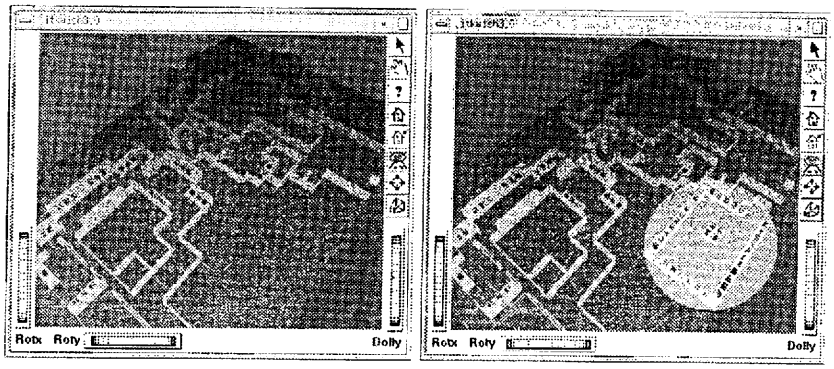


Figure 8: Floor map of Virtual Rekihaku without/with the personal gallery (left and right, respectively).

The example scenario is as follows. A visitor accesses the Virtual Rekihaku through the walk-through viewer and takes a glance at the gallery near the entrance. The visitor may want to know what kinds of objects are displayed and which ones can be seen in a limited time. He/she then looks at the Exhibition Space visualized by Mediator and then selects some objects, probably intuitively though this does not matter. Visualizing the Interest Space and the Personalized Space, Mediator shows the category window so that the visitor can select one category and then notifies CMC of the recommendable objects. CMC creates the personal gallery to fit the number of objects and then places the objects as shown in Figure 9. The visitor enters the personal gallery first and enjoys the exhibition for himself/herself. After that, the visitor again accesses the original exhibition and visits galleries to see the other objects or to know how the same objects in the personal galley are related to the entire exhibition.

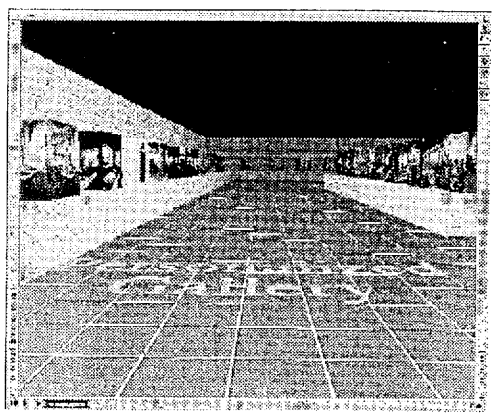


Figure 9: Example of personal gallery created in Virtual Rekihaku.

4.3 Personal Exhibition

In contrast with the personal gallery, the personal exhibition is a whole rearrangement of the original exhibition. That is, as many personal exhibitions exist as visitors, and none of the visitors share the same exhibition. In that sense, there is no original exhibition but instead a collection of objects and an archive of information. The difference between an exhibition and a collection of an archive is whether the scenario to organize the objects semantically is given by curators or not. This situation resembles people retrieving information from a database. To get a better result, they need the expert's help such as know-how on suitable keywords or databases. Since the concept of Meta-Museum is to exploit the expert's knowledge to give people a better understanding of exhibitions and more fruitful museum experiences, we do not put stress on the personal exhibition.

4.4 Discussion

The personal tour course recommendation described here is not a straightforward personalization of arrangement, as mentioned before, but a quite feasible approach for traditional museums. It is also a useful technique in virtual museums too because people have the freedom to move vertically in three-dimensional virtual museums, which means they must pay attention to one more dimension in comparison to traditional museums. The function of personal tour course recommendation, especially an autopilot tour, is to reduce the visitors' burdens or worries about whether they are missing important or worthwhile objects.

On the other hand, the personal galley can provide total personalized arrangement to each visitor, though actually this approach is not suitable for traditional museums. However, in Meta-Museum, as it is an integrated environment of traditional and virtual museums, a personal galley could be realized virtually while the real exhibition is also held. That is, visitors could create and walk around the personal galley in a computer-equipped room of a traditional museum before they actually walk around the real museum.

As for the personal gallery in Virtual Rekihaku, we need another recommendation mechanism different from that of Mediator. Virtual Rekihaku can create a personal gallery based on the visitor's interest while the order in which the objects are placed is based on the original order; this is due to the algorithm that Mediator employs. Mediator can categorize object pairs but cannot give an order to align the objects according to a certain criteria, e.g. similarity to the specified keyword as usually used in information retrieval systems. Arrangement personalization in a more detailed or lower level of an exhibition requires a new mechanism that can handle the order of objects while preserving the original semantic structure. Developing such a mechanism is one of our future works.

Also we are considering enhancing the arrangement personalization to fit the dynamic change of the visitor's interest. A visitor's interest may change after looking at some objects and may become clearer. The system could dynamically reflect the interest to recommend objects and to arrange them if it can detects the visitor's minute-to-minute evolving interest and/or context.

5 CONCLUSIONS

Although the two applications described in Section 4 are in a very preliminary phase, we believe that they illustrate the concept of personalization of arrangement very well and are good starting points for building more sophisticated systems to meet visitor requests. We demonstrated Virtual Nara City in our open-house exhibition held at our research laboratory on November 5-6, 1998, and the response of the visitors was quite satisfactory. This could be considered to be evidence supporting our belief.

In this paper, we have discussed the personalization of arrangement in the museum context. Nevertheless, this does not limit the domains to which the arrangement personalization is applicable as this is becoming more and more important to a wider area. For example, the explosion in the amount of information on the Web has caused a situation where people have to waste time looking at extra web pages before reaching the desired pages. They often try to find the desired pages by using search engines, which lack the capability of expressing the relation among obtained pages. The personalization of arrangement, therefore, is one of the most important issues to be further investigated in the computer age.

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