A Study on a Viewing System for Museum Collections using High-Definition Images

Fumio Adachi, Takuzi Suzuki and Kimiyoshi Miyata
National Museum of Japanese History
Sakura, Chiba, Japan

Abstract

Museums hold various collections consisting of several hundreds or thousands of artifacts. A viewing system for exhibiting images from a collection simultaneously as well as efforts to find an objective material for historical research have been discussed. A new means of display can be realized through the application of a super high-definition free viewing system to arrange the graphical data containing individual artifact images. A user can search an objective image by zooming in; continuously displaying the whole collection of images while comparing its surroundings on the display and can observe its detail directly.

To apply the viewing system to an exhibition with images arranged freely and enable display of the retrieval image, a method of reading out hierarchical imaged data of individual artifacts upon specific request or as a result of retrieval has been introduced. This method is applicable for image retrieval when the number of overall hits is below 200 or so. However, for exhibitions with greater numbers of artifacts, rearranged image data generation for layers with small magnification ratios is applicable.

An analysis of log data has revealed that general user views involved arrayed images over a relatively wide range of magnification ratios and users who searched for objective material often viewed arrayed images with 50 to 200 images displayed simultaneously. It becomes clear that the simultaneous display of over a thousand images and free display at a size appropriate for users is effective in terms of displaying and searching images within a collection.

Introduction

Museums hold various collections, consisting of several hundreds or thousands of artifacts. Only certain artifacts from collections are displayed at any one time due to limited exhibition spaces. Some kinds of artifacts sensitive to light and faded have a restricted duration governing their display in a year, rendering electronic means of display particularly useful. Within the domain of historical research, although the original material is an object of investigation, an electronic support system is also required at the stage where researchers seek their objective resources from a wealth of historical materials. Retrieval based on catalogued data is often used for this purpose. However, visual observation and confirmation of materials is required for cases where the object cannot be specified by catalogue data, such as drawings, paintings and artifacts of a characteristic shape. Therefore, a viewing system facilitating object searches for numerous materials is required, even for research purpose. The viewing system must also be applicable for use with detailed observation of detected objects and allow comparison with related artifacts through high-definition images.[1]

In conventional image viewing interfaces, steep magnification is used. A list indicating thumbnail images is initially shown to the viewer and a standard size image displayed when the viewer selects an objective thumbnail. An enlarged image is then displayed according to the viewer's request. This method includes the following problems and inconveniences: a viewer cannot observe the part of the object they find most interesting at the desired size and range and must return to the initial menu list each time to view other images. An interface giving the user freedom to look for objective artifact images from a selection of many images and to observe the selected image at their preferred magnification is required.

The National Museum of Japanese History has developed a super-high-definition free viewing system allowing the desired portion of an extremely large image to be viewed at an appropriate size by seamlessly shifting on the image and allowing continuous magnification.[2] Application of this free viewing system to a retrieval service has also been discussed.[3] This paper proposes a new viewing method for images in a collection, involving the application of high-definition images that will display plural artifact images simultaneously and allow a viewer to view objective examples by comparing the periphery on the display and observing the chosen image in detail. The paper also describes a means of configuring image data that can be adapted to a free arrangement following feedback from an inquiry or an arbitrary layout and discusses the potential applications of this viewing system as a system for displaying retrieval results, from the perspective of processing time. Finally, evaluation results concerning simultaneous enormous image displays for an exhibition and object searches based on log data obtained from an exhibition is described.

Outlines of the Super-High-Definition Free Viewing System

The super-high-definition free viewing system has been developed for the observation of large and finely depicted historical artifacts, such as folding screens, old maps or scroll paintings, in whole or in part, through seamless changes in the viewing position and magnification ratio. The free viewing system can handle image data as large as 100,000 × 100,000 pixels or more. This capability is required to read out an object artifact depicted in dimensions of 3 or 4 mm based on an original length of 10 m.

The screen layout for the viewing system is shown in Fig. 1. Almost three quarters of the screen is assigned for the image display area, while a map is located on the bottom left of the screen; indicating the relative position of the currently displayed image through a rectangular frame superimposed on the figure of the artifact. An explanation of the currently displayed portion of the artifact on the image display area can be indicated in the central bottom area. Image control buttons are arranged on the bottom right of the screen. Slight magnification and reduction is available, as well as double and half options in this system and users can constantly zoom in and out of the image on a practical basis. Clicking on any position of the displayed image area also zooms the image twofold, centering on the point clicked. Dragging on the image display area changes its viewing position while clicking on the map also changes it.

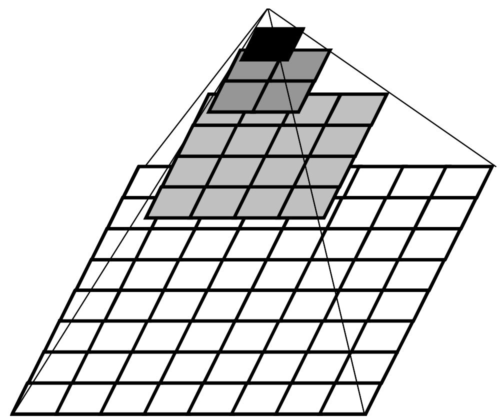
Image operations such as zooming or shifting can be executed on an ordinary PC without any slowdown.

Figure 1. Screen layout of the viewing system

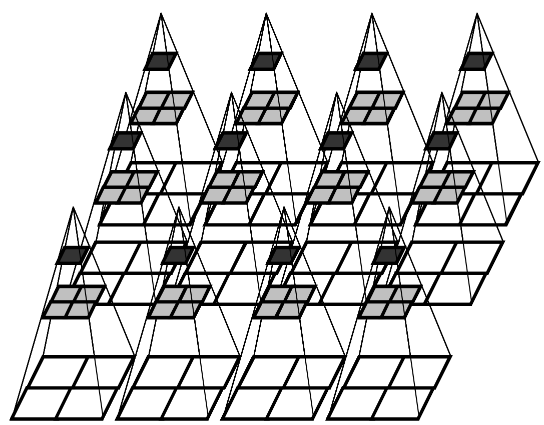
Image Data Configuration Method

The display of collection images based on certain search conditions or in a particular order is basically made possible by placing the images of individual artifacts alongside each other to form a single unbroken larger image and applying this latter to the free viewing system. The size of such expanded images is 60,000 × 30,000 pixels in each case, when images are arranged with 30 horizontally by 10 vertically and high-definition images, for example 2,000 × 3,000 pixels as used for recording in ProPhotoCD, are applied. Conse-quently, the free viewing system has sufficient ability to display several hundred high-definition images simultan-eously. However, the following problem will occur when the expanded image is generated using simple means.

For the swift display of a very large image at any magnification ratio, the following method has been adopted for use in the viewing system. Firstly, reduced-size images at several fractions of the original magnification ratio are pre-prepared and divided into certain sub-images of a size facili-tating reading, to form a hierarchical structure as shown in Fig. 2 (a). The system then reads only the image data neces-sary for displaying the designated position and the magnify-cation ratio based on information indicating the specific arrangement of the hierarchically divided image data.



(a) for an image of a single artifact



(b) for images of a collection

Figure 2. Image data configuration

Although display of collection images is basically possible by producing hierarchical image data of the arranged images, considerable processing time is required to create the arranged hierarchical image data, greatly extending the turnaround time required in the application of the retrieval image display. This problem can be solved, however, as follows without the need to create hierarchical rearranged image data, namely; pre-preparing hierarchical image data corresponding to each artifact, as shown in Fig. 2 (b), as well as the details of arrangement in advance, generating information for arrangement which corresponds to the retrieval result or an order request and then reading out the image data according to the arrangement information generated.

Application to Retrieval Image Display

Feature of the Displaying Method

Examples of the retrieval image display are shown in Fig. 3 and 4; applying the viewing system and the image data configuration method to 231 *Kosode* kimonos of the Nomura Collection of National Museum of Japanese History. The original image size of a kimono is 1,800 × 2,200 pixels. This collection includes catalog information such as the production period, ground color and technique in addition to individual names or identifying numbers. Retrieval or image arrangement can then be executed using this information as a key. The query condition of Fig. 3 (a) and (b) is that the ground color is "white" and the production period is "the middle of the Edo period" respectively.

(a) ground color = "white"

(b) production period = "middle of the Edo period"

Figure 3. Examples of retrieval images display

Figure 4. Appearance of zooming in on an arranged image (ground color = "purple or dark blue")

Figure 5. An example where all images of the kosode collection are displayed (ground color order)

Figure 4 shows a result where the ground color is "purple or dark blue" and also shows the appearances when zooming in. As shown, a user can search an objective artifact after viewing all images provided in response to the inquiry and perform comparisons by zooming and shifting the arranged images. A user may also observe the detail of objective artifacts by zooming in directly using its high-definition image.

An example where all of the images of the *Kosode* collection are displayed is shown in Fig. 5, illustrating a special case of a loose inquiry condition. The images are arranged using the ground color as a key. As shown in the figure, the outline in terms of the shape and tone of a kimono can be recognized, even when around 200 images are displayed at once, despite the size of the image display area being restricted to 1022 × 556 on an XGA display device. Consequently the viewing system enables a user to locate objective material from an arranged image where individual images are ordered concerning property and zooming in on interesting portions can be done gradually without limiting the number of hits to several tens.

The decision to limit the number of hits or not depends to a certain extent on how the range of the search target is fixed, how precisely the query can be described and the number of candidates existing. In both cases, an easy search of an objective image can be achieved by display methods allowing the user to view candidates at an appropriate size in relation to its surroundings. This method is suitable especially for cases when a user is searching for an object based on uncertain information.

Applicability from the Perspective of Processing Time

The processing time from the reception of retrieval results to the end of image display consists of generation time of arrangement information and time for drawing the images. Although the generation of arrangement information is executed by a program using macro language, the overall processing time is sufficiently short for practical use when the number of hits is several tens or less. However, delay in drawing all images is noticeable when the number of hits exceeds twenty or thirty, because the proposed image configuration method needs to read out the same number of files as the number of hits. The delay and time taken to generate the arrangement information cannot be ignored when the number of hits reaches around two hundred. Consequently, the applicable condition of this displaying method for image retrieval application is considered to be limited to cases where the number of hits does not exceed around 200 or so.

For exhibition applications, only the delay of image drawing becomes a problem because although arbitrary arrangement of artifact images is required, data preparation in advance is permitted. The delay in drawing whole images is also shortened by generating rearranged image data for layers of small magnification ratios only.

Application for Simultaneous Display of Collection Images

The possibility of exhibiting collection images to the public can be considered, by means of division into several groups or arranging the images according to a certain order. In this case, the issue of the number of images which can be displayed simultaneously for effective viewing becomes problematic. The same problem occurs during use for research when many items are the object of loose inquiry conditions or all artifacts in a specific collection are targets for visual observation.

It has been shown above that a single approximate shape and shade can be recognized from a simultaneous display of 231 Kimonos. Further investigation has been executed using a Nishiki-e (colored woodcutting) collection to reveal how many images can be displayed simultaneously during exhibition and search for objective material.

2272 Nishiki-e images, part of the Nishiki-e collection of the National Museum of Japanese History, were exhibited using the free viewing system alongside several original Nishiki-es in a special exhibition of the museum. At the Nishiki-e's corner, leaflets including one of the displaying original Nishiki-e in printed form were provided to tempt visitors to look for that one on the system. Users of the viewing system consist of participants in the search trials and individuals viewing freely without searching for the image. Logging data, recording user operations, were collected through the term of the exhibition and operational characteristics of both the overall and searching users were analyzed.

The display conditions of the collection images were as follows. A 50 inch display device with a touch-screen was used, operable by viewers' finger presses. High-definition images of Nishiki-e were applied, with the image size of an individual Nishiki-e sheet of 2000 × 3000 pixels. Whole images were arranged into a rectangular shape, to a horizontal-vertical ratio 2:1, corresponding to the aspect ratio of the image-display area. The arranged image was 208,000 × 101,000 pixels. This system reverts to the initial state of display in the absence of user intervention within two minutes from the previous operation. The magnification ratio for displaying image in their initial state was set to -6 or -7 powers of 2 of the original image size. In this paper, we call *r* the magnification level when an original image is magnified and displayed at a ratio of -*r* powers of 2. An enlarged image is displayed for a smaller magnification ratio, while 200 or 800 sheets of Nishiki-es are displayed on the image displaying area at magnification levels of 6 or 7 respectively. An example of the Nishiki-e images at magnification level 7 is shown in Fig. 6.

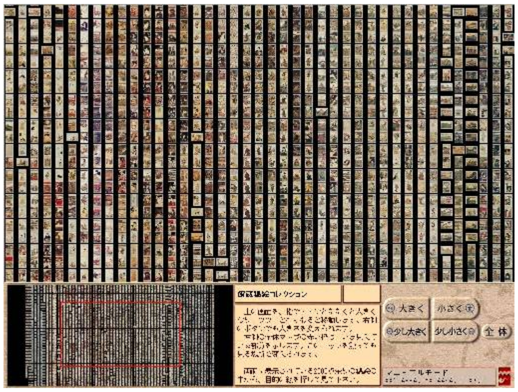
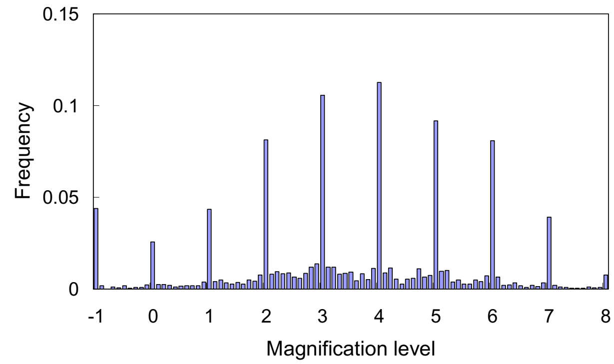


Figure 6. An example of displaying the Nishiki-e collection. Approximate 800 Nishiki-e are displayed on the main window.

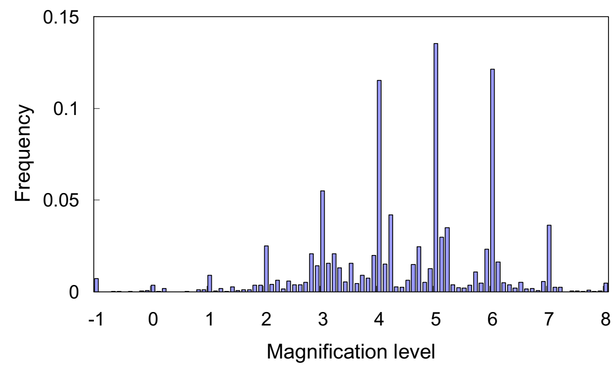
The data for each operation, in terms of buttons pressed or interventions on the image displaying area are recorded continuously as logging data, namely: time, coordinates of the displayed image, magnification level and so on. For extraction of the object to find out user's operations, terms and non-user terms of the system must initially be distinguished from the continuous records. Two types of terms are distinguished by observing the interval between operations that is longer than the threshold calculated using statistical method.

The following method was used to extract operational sequences from users who found out the objective image from those extracted using intervals. A sequence with coordinates situating it in the objective image area is considered to be a candidate for that detected. Sequences where the term from the start of usage to the revealing of results is less than five seconds are omitted from the candidates for exception those of users who find out the object immediately following the discovery of a previous user. Moreover, sequences of which term in the objective image area is less than five seconds are omitted from the candidate to remove those of users who do not search the object and which fall into the center of display area by chance. The residual candidates are regarded to be the detector's sequences.

Distributions of magnification levels for overall and detecting users, obtained by the above method, are shown in Fig. 7 (a) and (b) respectively. The period of the log data collection was four weeks with the number of overall users calculated by the log data 1200 and that of detecting users 110 respectively. The reason for the distribution density at the integer magnification level is the increased number of operations during two and a half times zooming as compared to slight zooming.



(a) overall user



(b) detector

Figure 7. Distributions of viewing magnification ratios

Figure 7(a) shows users with overall view arrayed images at a relatively wide range of magnification levels, although viewing at magnification level 4 and its surroundings is large where Nishiki-es are displayed with columns of 3 and rows of 5. At a magnification level of 2.5, the entirety of a Nishiki-e is just displayed within the image display area. The ratio of viewing operations below magnification level 2.5 was 24%, meaning a fairly large percentage involved enlarged views where a Nisiki-e image exceeds the display area and means that the application of high-definition images is effective for exhibitions. The usage over magnification level 5, where about 60 images are displayed, also takes large amount. This means that a display method enabling users to view arrayed images at an appropriate ratio via free zooming operation is useful when viewing large amount of collection images.

Figure 7(a) and 7(b) show that the average magnification level that detecting users use is larger compared with that of overall users. The average of the magnification level is actually is 3.52 for overall users and 4.47 for detecting users respectively. It can also be seen from Fig. 7 that the distribution of detecting users is concentrated compared with that of overall users, with variance of overall and detecting users 4.23 and 2.23 respectively. Accordingly, it becomes evident that overall users view images over a wide magnification range while they zoom in or out of an image while conversely, detecting users look for an objective images without frequent zooming in.

The difference between the average magnification levels of the overall and detecting users respectively is approximately 1. This value means searching user views at a magnification ratio of a half and displaying four times the number of images compared with overall users. The most frequent value of the distribution shown in Fig. 7(b) is 5 and the next most frequent value 6. This means a searching user typically looks for an object displaying 50 to 200 images on a display and shifts the displayed image. It can be concluded that a method displaying over a thousand images simultaneously and providing users with a free viewing facility is effective when searching for an objective artifact from an enormously large amount of collection images.

Conclusion

An image data configuration method for a viewing system applicable for high-definition and a large amount of collection images is discussed and the display method evaluated through analysis of log data obtained from an exhibition. The followings become apparent based on this study.

An arbitrary arranged display of collection images can be executed by reading out hierarchical image data of individual artifacts according to requirement of display and its order without making out hierarchical rearranged image data. Practically small processing time for retrieval image display can be achieved by this image configuration method when the number of displaying artifacts is smaller than about 200. When displaying images exceeding this number, the time taken to generate the layout data and reading out the whole image data when displaying overall images become too great to ignore. The latter problem can be solved by creating rearranged image data for layers at small magnification ratios and the image configuration can be applicable to exhibitions with freely arranged image collections.

A general user views arrayed images over a relatively wide range of magnification ratios where the outline images or enlarged images are displayed. The simultaneous display of collection images in high-definition is effective for electronic exhibitions of collections. A user who looks for an objective artifact often views arrayed images with 50 to 200 images shown simultaneously on a display. The simultaneous display of over a thousand images is effective for image searching purposes. This display method is applicable when searching an object from a large amount of artifacts and based on uncertain information.

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Biographies

Fumio Adachi was engaged in researches on visual information system at NTT laboratories from 1978 to 1999. He is a professor of the National Museum of Japanese History since 1999. His current interests include digital systems for historical research and museum applications. Dr. Adachi received his B.E., M.E. and D.E. degrees in electronic engineering from Tohoku University in 1973, 1975, and 1978 respectively. He is a member of the IEICE, the IPSJ, the IIEEJ and the ITE.

Takuzi Suzuki received his Master degree in Engineering from the University of Electro-Communications, Tokyo, JAPAN in 1990. Since 1994 he has worked as a research associate in the National Museum of Japanese History, Chiba, JAPAN. His subject is color science and museum information system. He is a member of the Information Processing Society of Japan (IPSJ) and the Color Science Association of Japan (CSAJ).

Kimiyoshi Miyata received his Ph.D. degree in imaging science from Chiba University in 2000. He joined the Department of Museum Science at the National Museum of Japanese History in 2001. He was a visiting researcher at the University of Joensuu, Department of Computer Science, Finland in 2003. His research interests concern applications of digital imaging studies to museum activities. In 2000 he was awarded the Progressing Award and Itek Award from SPSTJ and IS&T respectively.