Photomosaic Generation for Photograph Collection Browsing

Kiho Sakamoto
Ochanomizu University
2-1-1 Otsuka, Bunkyo-ku, Tokyo, JAPAN
+81-3-5978-5399
keyhole@itolab.is.ocha.ac.jp

Takayuki Itoh
Ochanomizu University
2-1-1 Otsuka, Bunkyo-ku, Tokyo, JAPAN
+81-3-5978-5900
itot@is.ocha.ac.jp

ABSTRACT
A Photomosaic arranges many small photographs to represent a large image. Our study applies the photomosaics to a photograph browser CAT. Our implementation displays photomosaics while zooming out, and individual photographs while zooming in. Here, many photograph browsing software displays a set of photographs in the order of their times. To maintain this order of photographs, our photomosaic generation technique firstly arranges the given set of photographs in the order of those times, and then retouches so that the set of photographs forms a photomosaic-like scene. This paper presents our technique for photomosaic generation, and a user evaluation to discuss what kinds of photographs are preferable to be applied. We think this discussion should be fruitful for our future development of automatic photograph selection for photomosaic generation.

Categories and Subject Descriptors
I.4.0 [**General**]: IMAGE PROCESSING AND COMPUTER VISION – *Image displays* I.4.10 [**Image Representation**]: IMAGE PROCESSING AND COMPUTER VISION – *Hierarchical*.

General Terms
Algorithms, Design, Experimentation.

Keywords
Photomosaic, Zooming Interface, Image processing.

1. INTRODUCTION
We often store a large number of photographs due to the digitalization and downsizing of cameras. Photograph browsing [1, 2, 3] has been an active research topic, which assists users to explore and browse the large number of photographs. We focused on the development of a new photograph browser featuring an artistic representation in addition to the all-in-one display of sets of photographs, because we think such features would make photograph browsing more enjoyable. Based on this discussion we focused on applying a photomosaic to the photograph browser. Photomosaics is a technique to generate large images representing particular scenes, by arranging large numbers of small images. We feel photomosaic is very artistic and enjoyable, because it looks like a particular scene of impressionism while zooming out, or a set of well-arranged scenes while zooming in.

This paper presents our study on application of photomosaic to a photograph browser CAT [1], which features a level-of-detail control with a zooming interface. Supposing the given set of photographs is hierarchically clustered, CAT displays representative photographs of higher clusters while zooming out, or individual photographs in the clusters while zooming in. This feature effectively assists interactive exploration of large photograph collections. Here, our study replaces them by the photomosaic images. The new photograph browser displays photomosaic images while zooming in, or individual photographs while zooming in. This feature improves the smoothness of the photograph replacement between representative and individual photographs. The paper consists of three parts: 1) a new technique to generate photomosaic-like images and its application to CAT, 2) a user evaluation to discuss what types of photographs are suitable to be applied to the photomosaic generation, and 3) a new technique to select adequate representative photographs by reflecting the user evaluation result.

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2. RELATED WORK
2.1 Zooming Interface for Photograph Browser
This study applies a photograph browser CAT [1] which features a zooming user interface. We suppose that photographs are hierarchically clustered, and representative photographs are selected for each cluster. CAT places photographs in the rectangle subregions of the display space by applying a space-filling algorithm featured by a hierarchical data visualization technique "HeiankyoView"[4]. CAT also features a level-of-detail control technique with a zooming user interface. It displays representative photographs as shown in Figure 1(a)(b) while zooming out, and individual photographs as shown in Figure 1(c) while zooming in. Other existing photograph browsers such as PhotoMesa [2] also features automatic photograph placement algorithm and zooming user interface; however, we think CAT is better for our purpose because it displays representative photographs in the appropriately sized and shaped rectangular subregions while zooming out.
CAT had a problem that the switch of displayed photographs may look very sudden. We expect applying photomosaic as representative images of the clusters would solve this problem.

2.2 Photomosaic Generation
Automatic photomosaic generation is an active research topic. AndreaMosaic [5] is an orthodox technique, which selects small block images based on color matching and places them in a reticular pattern. Gianpiero et al. [6] presented a unique technique, which generates randomly edged small block images based on the edges of the original image, so that the generated photomosaic well preserves the edges and shapes in the original image. These photomosaic generation techniques arranges block images based on local similarity of colors and shapes. In other words, they do not consider the semantics and meta information of photographs for their arrangement. We think it is inconvenient to search for particular photographs. To solve the problem, this paper proposes

a technique to generate photomosaic-like images from the sets of block images arranged in the order of timestamps.

(a) (b) (c)

Figure 1: Example of zooming operation of CAT. (a)(b) Display of representative images while zooming out. (c) Display of individual images when zoomed in.

3. PHOTOMOSAICS FOR PHOTOGRAPH BROWSERS WITH ZOOMING USER INTERFACE

This section presents a new photograph browser, which displays photomosaic as representatives of clusters of photographs. This strategy makes interactive exploration of large photograph collection smoother.

This section calls the reference image for photomosaic generation "the *representative image*", and a set of arranged small images "*block images*". The new technique for photomosaic-like image generation presented in this paper firstly arranges the given set of block images in the order of their timestamps, because it makes it easier for users to look for particular images. The technique then retouches the arranged block images so that they look like the particular scene in the representative image. It repeats the arrangement of block images, if the number of blocks is larger than the number of block images.

The technique applies the HSB color system for block image retouching. The HSB color system describes colors by three variables: hue, saturation, and brightness. This technique calculates the RGB values of the each pixel of the final image, from the HSB values of representative and block images. Let the average HSB value of a block image $(\bar{h}_1, \bar{s}_1, \bar{b}_1)$, the average HSB value of the corresponding block in the representative image $(\bar{h}_2, \bar{s}_2, \bar{b}_2)$, and the ratio of saturation and brightness between the former and latter average values, $s_{12} = \bar{s}_2 / \bar{s}_1$ and $b_{12} = \bar{b}_2 / \bar{b}_1$. This technique retouches the HSB value (h, s, b) of a particular pixel by the following equations:

$$h = \bar{h}_2$$

$$s = s \times s_{12}$$

$$b = b \times b_{12}$$

The above formulation substitutes the average hue of representative image to the hue of all pixels of the block. They also multiply the ratio of average saturation and brightness to the saturation and brightness of each pixel of the block image. This formulation preserves the silhouette of the scene of the block images while retouching the hue.

Figure 2 shows an example of a photomosaic generated by our technique. Figure 2(a) is the photomosaic generated from 174 photographs used as 60 by 45 pixels of block images. The representative image is divided into 5, 256 blocks, and therefore the block image arrangement process is repeated 30 times. Figure 2(b) is a partial zoom-up of the photomosaic images. This zoom-up view shows that people or mountains are taken in the block images. Their colors are much different from the colors of real people or mountains, but we can recognize them from their silhouette in the block images. Then the browser switches the displayed images from the photomosaic images to the input images as shown in Figure 2(c). This switch looks very smooth, because it just changes in the hue of the images. Figure 2(d) is a partial zoom-up of the input image.

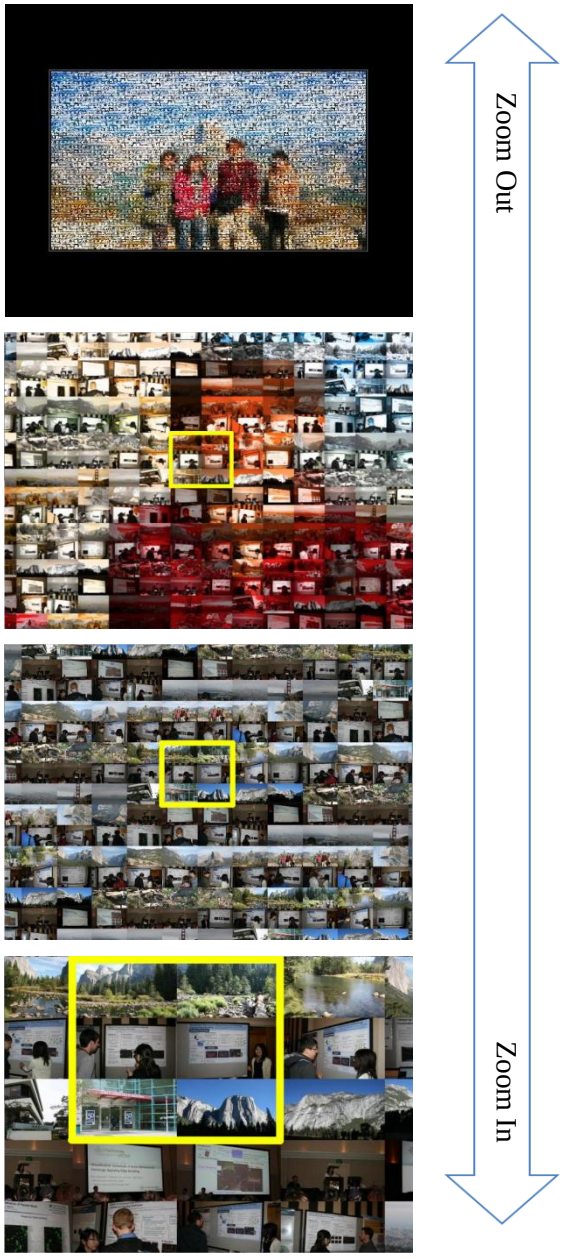

Figure 2: Zooming operation with a photomosaic image.

(a) Photomosaic generated by our technique

(b) Partial close-up

(c) Switched to the original photographs

(d) Close-up to some of the original photographs

4. EVALUATION OF PHOTOMOSAIC

It is important to reduce manual operations to make photograph browsers easier and convenient. Therefore, automatic representative image selection is an important problem for the photograph browsers featuring the zooming user interfaces. This problem itself is a very difficult problem, and therefore many studies [7, 8] have been already presented. Here, we found it is important to discuss the difference what kinds of photographs are preferable as representatives between general photographs and photomosaic. Therefore, we conducted a user evaluation of the preferences of photomosaics. We showed 39 photomosaics generated by our technique to 28 subjects, including who doesn't know about the photographs, and asked them to answer the questions regarding the preference for photomosaic; for example, "which representative image do you think the best to be the photomosaic?" as five-level rating evaluations. We prepared photograph collections of abroad trips, and generated several photomosaic from each of the collections. We randomly selected four to eight pieces of photomosaic for each question.

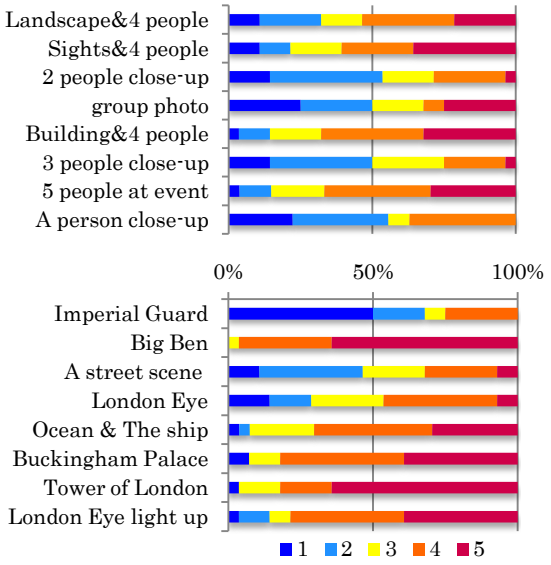

Figure 3: Result of user evaluation. (Upper) Persons in the photomosaic. (Lower) Landmarks in the photomosaic.

Figure 3(Upper) shows an evaluation result of photomosaic where one or more persons are taken in the original photographs. The result denotes that photographs which take too distant or close persons (e.g. close-up and group photographs) had relatively low rating. We suppose that photomosaics may get bad impressions if the original photographs are focused only on human faces, because it is often difficult to identify who they are. We therefore think it should be careful to select photographs focusing only on human faces as representatives. At the same time, we found that subjects joined to the trips or parties could identify the persons taken in the photomosaic, while it was impossible to identify them for the other subjects who do know them.

Figure 3(Lower) shows another evaluation result of photomosaic where famous landmarks are taken in the original photographs. Big Ben and London Tower had relatively higher ratings among. We suppose the main reason of the higher rating is the contrast between the buildings and background, which makes the recognition of the landmarks easier, as well as these landmarks are famous. We suppose this knowledge may be useful for the automatic representative photograph selection, because it is possible to calculate the contrast between the buildings and backgrounds. This strategy is also good to avoid selecting too dark or single colored photographs as representatives.

5. DISCUSSION FOR AUTOMATIC REPRESENTATIVE PHOTOGRAPH SELECTION

We have an on-going work on the development of the automatic representative photograph selection based on the evaluation results introduced in the previous section, where the selected photographs are used for photomosaics. This section discusses the criteria for automatic representative photograph selection for the two types of photographs: ones which take landmarks, and other ones which take human faces.

We think the criteria to select representative images are different between ordinary photographs and photomosaics. When we are to select a representative image from a set of photographs, many people will prefer to select the photographs in which famous landmarks or persons are taken. This preference can be also applied to photomosaic selection, according to the user evaluation presented in the previous section. On the other hand, we found several differences of characteristic preferences between photomosaic of landmarks and persons. The following sections discuss the conditions for preferable representative image selections based on the evaluation results introduced in the previous section.

5.1 Condition for the Photomosaic of Landmarks

We conducted the following hypothesis from the evaluation results regarding the photomosaic of landmarks. First, the preference of photomosaic is related to the contrast between foreground objects and background. If the contrast is large as shown in Figure 4(a), it is easy to clarify and recognize the objects from background. Otherwise, the color of photomosaic is monotonic as shown in Figure 4(b). In addition, photomosaic tend to be preferable if they take large foreground objects placed around the center of the input photographs, as shown in Figure 5. We suppose these points are good criteria for the selection of preferable representative images of landmarks.

(a) (b)

Figure 4: Examples of photomosaics containing (a) large or (b) small contrast.

Figure 5: Examples of preferable photographs, which take large landmarks as indicated by blue circles.

5.2 Condition for the Photomosaic of Person

We conducted the following hypothesis from the evaluation results regarding the photomosaic of persons. First, the preference of photomosaic is related to the sizes of their faces in the photographs. We cannot enjoy looking at the background if the

sizes of faces are too large, as shown in Figure 6(a). Or, we cannot recognize the characteristics or expression the human faces if their sizes are too small in the photomosaic, as shown in Figure 6(b). As a result, we conducted that moderately sized faces bring well-balanced composition to generate photomosaic. In addition, large contrast between human faces and background will bring preferable photomosaic, as same as the photomosaic of landmarks. We suppose these points are good criteria for the selection of preferable representative images of persons.

(a) (b)

Figure 6: Examples of photomosaics containing (a) large or (b) small sizes of faces.

6. DEVELOPING TECHNIQUE FOR AUTOMATIC REPRESENTATIVE PHOTOGRAPH SELECTION

This section presents techniques for automatic representative photograph selection for preferable photomosaic generation, which are being developed based on the discussion in the previous section.

6.1 Technique for Photographs of Landmarks

Our evaluation concluded that photographs, which have larger contrast between landmark and background, are usually preferable as photomosaics. Also, we concluded that photographs are preferable if landmarks in representative images are large and placed at the center of a photograph, as shown in Figure 5.

Based on the above discussion, we are currently developing the following technique for the selection of photographs taking landmarks. Our implementation firstly reduces colors and removes noises by applying Mean Shift Filtering provided by OpenCV. It then labels the color segments, calculates their areas, and specifies the larger segments. It also calculates centers of the specified segments, and selects the segment, which is sufficiently large and close to the center. It then calculates the contrast between background colors and the colors of objects taken in the specified segment. Our implementation repeats the above process for all photographs, and selects the photograph, which has the largest contrast as the representative image to be shown as a photomosaic. We are currently designing the objective functions to adequately specify the photographs, which take landmarks sufficiently large and close to center, and have significant contrast between the landmarks and the background. We have to find out the photograph which have an object which area is large and place is around a center of a photograph.

6.2 Technique for Photographs of Persons

Our evaluation concluded that photographs with moderately sized human faces are better for representative images to be shown as photomosaics. Based on this discussion, we are currently developing the technique for the selection of photographs, which take human faces. Our implementation firstly recognizes human faces, and gets their sizes. It then selects the photographs, which take moderately sized human faces. Finally, it applies the processes developed for the selection of landmark photographs to select small number of representative photographs. We are currently developing this technique and testing the availability.

7 CONCLUSION

The former part of this paper presented a photomosaic browser applying photomosaic. This technique displays photomosaic as representative images on a photograph browser CAT. It realizes smooth switch of displayed images by applying photomosaic rather than original photographs. Moreover, we think this approach realizes more artistic photograph browsing.

The central part of this paper introduced a user evaluation to determine which kinds of photomosaic are preferable for representative images of the photograph browsing. We found that photomosaic of landmarks got higher ratings if contrast between buildings and backgrounds are clearer. At the same time, we found that photographs focused only on human faces got relatively lower ratings, because it is generally difficult to identify who are taken from the photomosaic. However, these images even got higher ratings from subjects who know the taken persons. We supposed that preference of the representative photograph selection depend on the possibility of identification of taken persons, according to the free comments of the subjects. We expect this aspect can be applied to the development of automatic representative image selection from the contrast between foreground objects and background scenes.

The latter part of this paper introduced the technique of automatic selection of representative image for each photomosaic, landmarks and persons.

Following are our future issues. We will complete the development of the automatic representative photograph selection technique, and discuss if the technique really selects preferable representative image. Also, we will find out the other conditions for preferable photomosaic generation. Especially, we will need to address the selection of the best photograph taking similar objects or scenes. Near-duplicate detection [8] is one of the useful concepts to solve the problem.

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