Intelligent Photo Management System Enhancing Browsing Experience

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Abstract. We developed a web-based intelligent photo management system which enables automatic clustering of unstructured personal digital photo collections. We conducted a user study to assess the usability of the developed photo management system (*automatic photo classifier*, APC) compared with ones with limited functions. The user task adopted here was finding some of target photographs indicated by an experimenter from the subject's personal or somebody else's photo collections. The results show that APC is better in the case of the personal photographs while it does not have a significant advantage for somebody else's photo collections. It was suggested that the look-and-feel of a photo management system should be considered according to whether the photographs had been taken by the user him/herself or not.

1 Introduction

Recent popularization of digital cameras and growing capacity with lowering price of storage media made consumers easier to take a huge amount of digital photographs. According to a certain research, we take more than 1000 of photographs a year. As the size of the personal digital photo collection grows, even just finding a target photograph becomes difficult. In most cases, people are satisfied just by taking photographs, and consequently the flood of the personal digital photo collection becomes dead storage in our personal computers.

There have been several approaches to activate these digital photographs for personal use. FotoFile [1] and PhotoFinder [2] use databases to support creating annotations for photographs. Although these systems have powerful search functionality, photographs have to be annotated manually by the user. PhotoMesa [3] utilizes novel layout mechanisms to maximize the screen-space usage, but again, users have to organize the photographs beforehand.

Using visual features to automatically group photographs is a popular approach. It is ideal to extract high-level semantic content from photographs automatically, and use this to index photographs objectively. But of course, this is a very difficult problem, and current systems can only extract low-level contents like color and texture. Rubner [4] proposed that a low-level content-based image similarity metric can be used to create an effective layout of sets of photographs, but he did not carry

M.J. Smith and G. Salvendy (Eds.): Human Interface, Part II, HCII 2009, LNCS 5618, pp. 439–447, 2009.

out any experimental evaluation. Rodden [5] showed that users generally find given photograph faster in the created layout than in a random arrangement.

Using timestamps is also a common approach. iPhoto [6] manages the photographs taken in the computer at a time as a "Roll", and the photographs in the roll are further divided into some of "Events" at a manually specified interval (e.g. a day, two hours, etc.). On the contrary, PhotoTOC [7] and its predecessor, AutoAlbum [8], proposed an adaptive time gap detection algorithm for adjusting the interval automatically. The photo management system developed by Graham [9] cluster photographs with similar function, but with a different user interface.

Based on the knowledge of user studies, most of the researches concluded that clustering the digital photo collection by the timestamp is one of the effective methods to separate contextually related groups.

Also, it is worth increasing the opportunity to see passively the photographs taken in past days, so as to make good use of the personal digital photo collection. So far, most of operating systems or photo browsing applications have slideshow function. The function, however, merely shows the photographs in random or predetermined order, and there has been no photo application that positively utilizes the slideshow function for efficient browsing.

In this study, we developed a web-based intelligent photo management system (automatic photo classifier, APC) which enables automatic clustering of an unstructured collection of personal digital photographs. To achieve a hierarchal structure with high affinity with human memory system, two stages clustering (into *Groups* and *Events*) was adopted in APC. It can also offer the chance to see passively the photographs taken in the past time by introducing *dynamic thumbnails*.

To assess the usability of APC and effectiveness of its functions, we conducted a user study. The user task adopted in this study was finding several target photographs chosen from the user's or somebody else's photo collections. The results show that APC works better for the user's own photographs, while it requires more time for others' photo collections. Although it has been reported "It is better that the thumbnails as many as possible can be seen at a glance [10]", the results suggested that the look-and-feel of the photo management system should be considered according to whether the photographs had been taken by the user him/herself.

2 APC: Automatic Photo Classifier

2.1 Clustering Method

Photographs taken by digital still cameras store metadata in EXIF (exchangeable image file format) [11] which includes timestamp, exposure time, camera settings, etc. The data is encoded into the digital photograph files, and is available to applications that access these files. As specified in [10], the timestamp seems to be highly useful in helping people browse their photographs. We also decided to use the timestamp in the EXIF data to cluster digital photo collections.

Our photo browsing system, APC, clusters photographs in two stages. In the first stage, all photographs are clustered using the k-means clustering algorithm [12]. Here, the number of the cluster, k , is given adaptively by rounding off

$$k = \alpha\{\log_{10}(N_1)\}^2 \tag{1}$$

where N_1 is the number of photographs in a collection, and α is a coefficient whose value is empirically chosen to be 1.3. Using this setting, the photos can be clustered into several similar sizes of bursts, each of which generally fits in a single pane. We call each burst a *Group*.

In the second stage, photographs from each Group are further clustered in a hierarchical bottom-up way using the NN (nearest neighbor) algorithm [12]. The clustering procedure will terminate if the shortest distance between two clusters becomes more than

$$T = \kappa \log_{10}\left(\frac{H}{N_2}\right) \tag{2}$$

where H is the time difference between the first and last photos in the Group, N_2 is a number of photos in the Group, and κ is a threshold coefficient whose value is empirically chosen to be 250 [sec]. By this setting, photographs in a Group can be organized into smaller bursts, reflecting the manner in which the photos are taken, thus expected to have higher affinity with human memory system. We call each burst an *Event*.

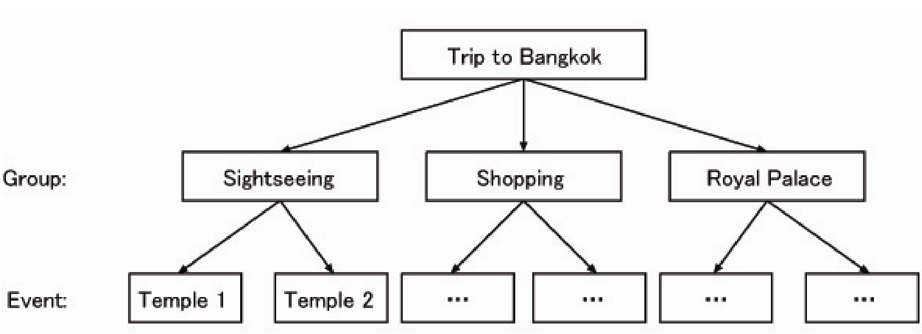

Fig. 1. Example of clustered photo collection

Figure 1 shows an example of a clustered photo collection. After the first stage of clustering, the photo collection is divided into Groups which can correspond to “sightseeing”, “shopping”, etc. After the second stage of clustering, each Group is divided into Events which can be interpreted as “Temple 1” and “Temple 2” in the “Sightseeing” Group.

2.2 Implementation

Figure 2 shows the appearance of the developed photo management system, APC. It was developed using PHP (version 5.2) with Apache HTTP server (version 1.3.33) and JavaScript.

Fig. 2. Appearance of APC

User interface of APC is partitioned into two panes. The bottom pane shows a page at a time, and each page contains photographs from one Group. Clicking white arrows in the bottom scroll pages. The photographs in each page are in chronological order and clustered into Events. The first photograph in each Event is shown in bigger thumbnail and clicking each thumbnail shows the full-sized photograph.

The top pane contains representative thumbnails which represent Groups. We call these representative thumbnails *dynamic thumbnails*. Rather than showing one representative photograph from each Group, a dynamic thumbnail consecutively shows the first photos of the Events in the Group. Clicking each dynamic thumbnail scrolls the bottom pane to its corresponding Group page.

3 Experiments

We conducted a user study to assess the usability of dynamic thumbnails and Event clustering. We compared three browsing conditions: APC, APC without Event (APC woEv), and APC without dynamic thumbnails (APC woDT). APC without Event shows dynamic thumbnails, but it does not cluster photographs into Events. APC without dynamic thumbnails is *vice versa*: it clusters photographs into Events, but does not show dynamic thumbnails.

Figure 3 shows the instrumental computer layout for the user study. We used two computers: the one set on the participant's right-hand side showed a target photograph to be found while the left-hand side one was used as the photo management system with one of the three conditions. The participants were asked to use the photo browsing

Fig. 3. Instrumental computer layout

system and find the target photographs. When he/she found one, the next target was shown. Needed time to find each target was measured as a task completion time.

We tested six participants (four males and two females, age: mean 24.0 ± SD 5.0). All participants were relatively experienced computer users. The user study was formed by two parts.

In the first part, participants were asked to find the target photographs from somebody else's novel photo collection (660 photographs). We divided these photographs into three groups (each contained 220 photos) in chronological order, and assigned them to the three browsing conditions. For each browsing condition, participants were asked to find randomly chosen 11 photographs (first one was for practice and remaining 10 photos for the actual test).

In the second part, on the other hand, these participants did the same task with their personal photo collection. Each participant provided a digital photo collection ranging from 263 to 436 photographs which were taken in trips between four to seven days. We divided participant's own photographs into three groups and asked them to find randomly chosen 5% of each group (4–7 photos) as the targets. At the end of user study, participants answered questionnaire sheets asking the usefulness of dynamic thumbnails and Event clustering, the validity of automatic clustering, etc.

4 Results

Table 1 and 2 show the average task completion times [sec] for the novel and users' own photo collections, respectively. In the first part, as shown in figure 4, average

Table 1. Average task completion times ([sec]) for the novel photo collection

Participant	APC woEv	APC	APC woDT
1	21.17	17.92	20.98
2	16.11	17.12	19.65
3	27.92	25.43	25.31
4	15.73	16.70	20.75
5	16.06	16.42	17.25
6	15.73	17.16	20.42
Average	18.79	18.46	20.73

Table 2. Average task completion times ([sec]) for participant's own photo collection

Participant	APC woEv	APC	APC woDT
1	8.85	9.04	16.06
2	13.93	11.49	12.92
3	9.68	8.91	9.94
4	10.89	9.07	12.89
5	17.29	13.19	9.02
6	17.25	10.81	16.80
Average	12.98	10.42	12.94

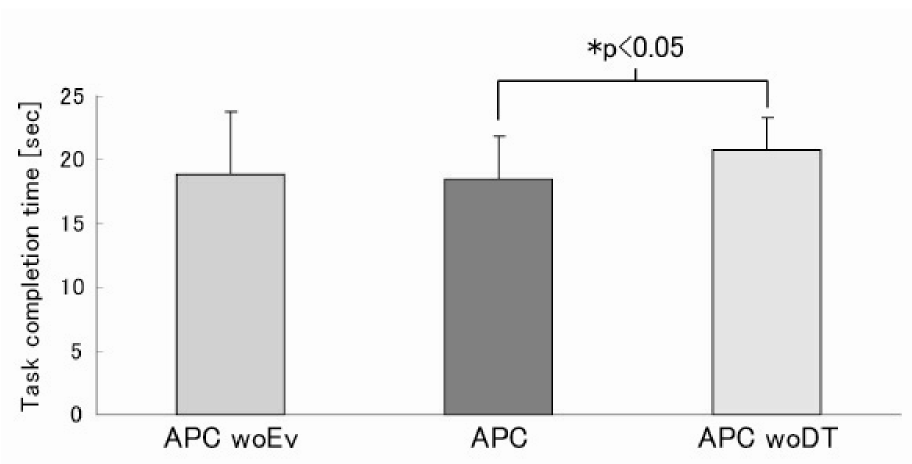

Fig. 4. Task completion time for the novel photo collection

task completion time for APC and APC woEv was almost the same. We saw a significant difference between APC and APC woDT using t-test ($p<0.05$). In the second part, on the average, participants achieved better task completion time on APC than on APC woEv and APC woDT. We also saw a significant difference between APC and APC woEv using t-test (*p<0.05*). From the questionnaire sheets, all participants specified that they felt easier to find the target photographs when clustered by Event (Likert scale of 6 levels: *M=5.33*). In addition, five participants also specified that they felt easier to find the target photographs with dynamic thumbnails (Likert: *M=4.83*) although one of the participants did not positively use dynamic thumbnails to move among pages.

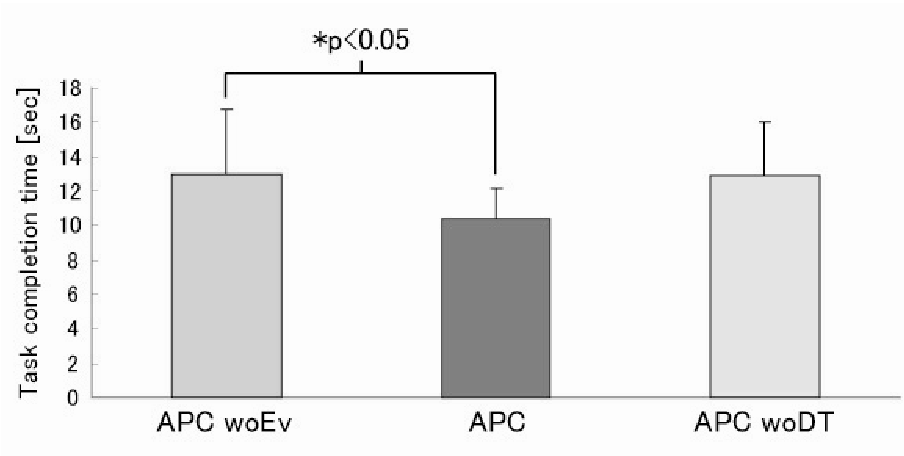

Fig. 5. Task completion time for participant's own photo collection

5 Discussions

The above results indicated that finding a target photo from the user's own photo collection can be made easier by using dynamic thumbnails and Event clustering. They also showed that Event clustering does not have a significant effect on novel collection.

From these results, we can suggest that by changing the look-and-feel of the photo management system according to whether the photographs had been taken by the user him/herself or not, one can improve the browsing experience. That is, for the user's own photo collection, the Event clustering can provide a structure which is in good accordance with the user's memory about the events. On the other hand, some clustering method based on visual feature similarity can be more effective for the management of novel photo collections.

The result of the user study did not confirm the advantage of dynamic thumbnails clearly. We think, however, we can confirm it when the time scale of the photo collection grows further, because it seems worthful offering the more chance to see passively the photographs taken in past days.

6 Conclusions

In this paper, we explained our web-based intelligent photo management system (APC) which enables automatic clustering of unstructured personal digital photo collections based on the photo-taking behaviors inferred from the metadata added to them. By introducing dynamic thumbnails, APC can also offer the chance to see the photographs taken in the past time, without the user's active effort. The results of user study showed that APC works better for the personal photographs, while it does not make large difference when he/she browses others' photo collections. It is suggested that the look-and-feel of the photo management system should be changed according to whether the photographs had been taken by the user him/herself.

7 Future Works

At the moment, APC only use timestamps to cluster photographs. However, we are in the process of developing newer version of APC which uses timestamps and visual feature of the photograph. We are hoping to see the effectiveness of the photo management system which combines the results of time-clustering and color-clustering.

Acknowledgments. This research was partially supported by the Ministry of Education, Culture, Sports, Science, and Technology, Grant-in-Aid for Scientific Research on Priority Areas (No.20033007), and "Symbiotic Information Technology Research Project" of Tokyo University of Agriculture and Technology.

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