Social Album: Linking and Merging Online Albums based on Social Relationship

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***Abstract*—This work designs a novel prototype system, *Social Album*, by utilizing social relationship data to link and merge online albums of individuals together. Field study results indicate that "co-event" albums related to more than one participating individual are the majority of online albums. Two different views are designed based on feedbacks from the interviews: the *indexing view* provides a metro-map such as an overview of the linked albums, while the *browsing view* allows individuals to peruse photos without looking at mis-aligned and duplicate photos from merged albums. Hence, through our system, *Social Album*, to share and gather "co-event" photos becomes much easier than before, and to browse the photos in the "co-event" albums also becomes more efficient while still keeping the comprehensiveness of the whole event. Finally, a user study demonstrates the usefulness of the proposed system.**

I. INTRODUCTION

Because of the advanced camera technologies, people right now can easily take photos while attending events and share their life experience with their families and familiar friends to update their current situations. There are many methods to share photos, and the most used way is to share them through the photo hosting website(s), such as Yahoo! Flickr, Google Picasa Web Albums, etc. Because right now, most famous social network service providers, like facebook, MySpace, Orkut, etc., also have the photo hosting service, people therefore often tend to upload their photos on the social website(s) to share their life events with their friends. To examine what people tend to share on the Internet, we conducted a field survey by observing many people's online albums.

According to our field study results, we found that most of the uploaded albums are related to the events that more than one person joined, such as travel, celebration, party, etc. For those kinds of albums, we call them as "co-event" albums, which are related to the events with multiple participants. Interview feedbacks reveal that individuals have difficulty in gathering and browsing photos taken during a "co-event". Event participants may record portions of the event through their own camera view explaining why the photos of other participants may be gathered after the "co-event". Although individuals may upload their own photos to online albums, the uploaded "co-event" albums are still solely under the owners' folders. Moreover, individuals encounter mis-aligned and duplicated photos when browsing gathered photos from different "co-event" albums simultaneously.

Frohlich *et al.* [1] devised the concept of multi-user album

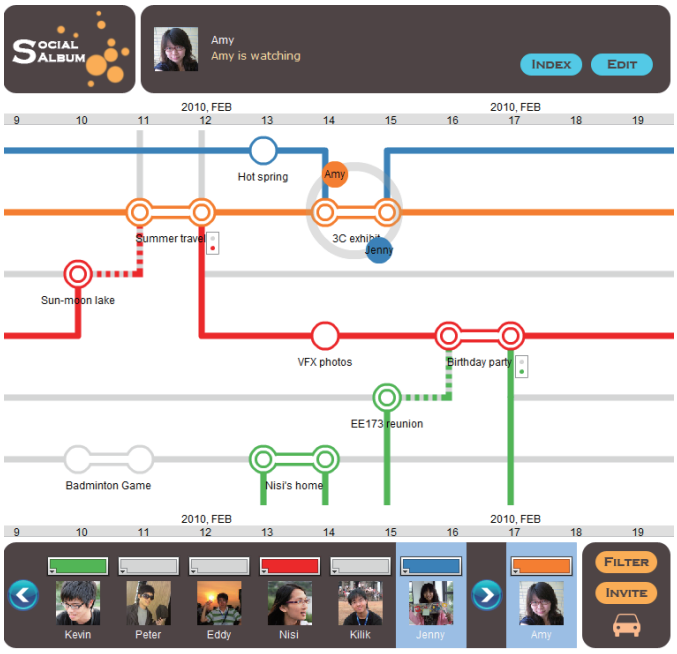

Fig. 1. Example of *Social Album*'s indexing view.

to allow users to share joint accounts. Although commercial services, such as Google Picasa Web Albums and Apple MobileMe, similarly allow users to authorize their friends to upload photos into designated albums, such mechanism is still difficult for users. Despite allowing the merge of albums from various hosting services, Memolane and Pictarine are still lack of the ability to utilize the existing social network to provide "co-event" browsing. facebook also only allows manually tagged photos to appear on the photo wall.

Nair *et al.* [2] developed the concept of using *Photo LOI* (level of interest) of photos to enhance the browsing experience of merged albums. *Photo Tourism* [3] further utilizes duplicated photos to construct the geometry of a specific scene. *PhotoMesa* [4] uses a space filling algorithm and zoomable user interface (ZUI) for users to review enormous album contents and zoom into a collection of photos smoothly. Nevertheless, these methods fail to consider the clock synchronization problem among cameras, leading to misalignment of the photos if the albums were merged arbitrarily.

While addressing "co-event" album gathering and browsing

issues, this work presents a novel *Social Album* by utilizing social relationship data to link and merge individuals' online albums. *Indexing view* and *browsing view* are designed for easily overviewing and browsing the linked and merged albums. Design of the *indexing view* is adopted the metro-map metaphor by treating an album as a station (i.e., node) and an individual as a railroad track. The metro-map concept has been used to portray abstract data, especially for navigation [5][6], due to its natural characteristics. Hence, browsing one individual's albums is similar to taking a train (of the albums' owner) and viewing the scenery (i.e., photos) outside a window. A "co-event" album can be treated as an "intersection" station (i.e., joint node) allowing viewers to "transfer" to other individuals' tracks. Due to the "intersection" stations, the tracks (i.e., albums' owners) can be linked together to form a metro network. Finally, photos in the "co-event" album are merged together and further aligned and grouped according to the similarity in the *browsing view*. The system is implemented on facebook, the largest photo sharing website and the largest social network worldwide.

In the following sections, we first review the related work, and then describe how we conducted the prior user study to elicit the design ideas. We then explain how we design our system and introduce the implementation details. Followed by detailed interaction design, we describe how we implement our *Social Album*. Finally, we discuss the evaluation results before concluding this paper.

II. RELATED WORK

The purpose of *Social Album* is to provide a new mechanism for online albums' users to easily access the "co-event" albums through a metro-map-like indexing view and to browse the merged "co-event" albums in a browsing view. Hence, the literature of our work includes the papers related to multi-user album, photo browsing and metro map metaphor.

Multi-User Album. Frohlich *et al.* [1] proposed the concept designs about the multi-user album software by using joint accounts on photo hosting websites to let users with intimate relationship be able to co-author and synchronize their albums. Considering that people may take pictures in the same event at the same location, Jung *et al.* [7] proposed the concept designs of *Photo Collage Camera* and *Co-Photographing* for users to watch the different viewpoints of the scene from each other's camera. Nair *et al.* [2] proposed a metric, *Photo LOI*, to indicate the LOI of the photos in the merged albums to enhance the browsing experience. Clawson *et al.* [8] provided a service on mobile devices to let a group of people capture and simultaneously share photos with each other. *Photo Tourism* [3] utilizes a large number of photos on a photo sharing website to construct the geometry of a specific scene, and then users can navigate smoothly between the photos inside the scene with the reconstructed camera viewpoints [9].

About commercial software and services, Google Picasa Web Albums and Apple MobileMe allow users authorizing their friends to upload their photos onto the designated albums. facebook does not only provide a photo wall for users to browse their friends' recent updated photos, but also allows them to browse the photos tagged with a specific friend in different albums at the same time. Although those works consider the multi-user scenario, they do not utilize the existed social relationship data to provide the "co-event" browsing.

Photo Browsing. Photo browsing issues can be generally categorized into representation and organization. In representation aspect, major research works aim to fully utilize the screen space to display more information. *PhotoMesa* [4] uses a space filling algorithm and ZUI for users to quickly review huge albums' contents and zoom into one collection of photos smoothly. *Time Quilt* [10] represents thumbnails using the space-filing layout. However, those works cannot represent the overview of several albums with relationship. To organize photos, time is usually an essential factor [11]. However, organizing photos by time usually suffers from the well-known problem of missing photos' EXIF information. Therefore, prior works usually consider other factors, which are shots' sequences, location information, and image content features [12][13][14]. Those features are also used to cluster photos to enhance photo representation [15][16][17]. Furthermore, face detection is also used in Google Picasa Web Albums and Apple iPhoto for photo organization. However, those services still do not take the social relationship as a factor to enhance the photo browsing experience.

Metro Map Metaphor. The concept of metro map has been widely applied to portray abstract data in recent years. Sandvad *et al.* and Bang *et al.* used the metro map metaphor as the web index to help navigation [5][6]. Nesbitt *et al.* [18] thought that the metro map metaphor is suitable for presenting "train of thought". Stott *et al.* [19] generated an automatic metro map layout to visualize project planning processing and found that the metro-map-like representation overcomes the limitation of Gantt Chart [20]. Additionally, Martínez *et al.* [21] applied the metro map metaphor to project management. Therefore, the virtue of the metro map metaphor is useful for navigating, so we further adapted the metro map metaphor in designing the indexing view of *Social Album*.

III. PRIOR USER STUDY

In order to know what kinds of photos people shared most in their online albums, we conducted a field study to observe the usage of online albums first and then found people would share "co-event" photos and albums mostly. Then, we conducted an interview to understand how online albums' users dealt with the "co-event" photos and albums.

A. Field Study

Through the intuitive understanding and observation, we found that lots of albums shared on the Internet are "co-event" albums. A survey was then conducted to understand the usage of online albums. The most three famous photo hosting service providers, i.e., facebook, Yahoo! Flickr and Google Picasa Web Albums, were selected. 55 users from Facebook, 22 users from Yahoo! Flickr and 15 users from Google Picasa Web Albums were randomly selected for the field study.

The result shows that the usage of online albums is quite different, from sharing life events to archiving personal data. The most shared life events are "co-events", like birthday parties, traveling with friends, reunions, family activities, ceremonies, celebration, company activities, etc. Few people also used the online album for archiving purposes, like showing the art work collections, the scanned paper sheets, or images used for explaining something in the online articles. From the statistics, individuals using Google Picasa Web Albums all have at least 1 "co-event" album. Only 1 Yahoo! Flickr user does not have any "co-event" album, and 45 Facebook users have at least 1 "co-event" album. About the details, more than 50% of the albums belonging to Google Picasa Web Albums users are "co-event" albums, and 4 users' albums even are all "co-event" albums. 17 Yahoo! Flickr users have more than 50% "co-event" albums, and 41 Facebook users have more than 50% "co-event" albums. Statistics thus confirm that most shared online albums are "co-event" related ones.

B. Interview

9 participants (6 females + 3 males, 21∼30 years old) were interviewed to understand how "co-event" photos are shared and browsed, as well as how individuals interact with online albums. In addition to their familiarity with online album services and having their own online albums, those individuals have their own cameras and usually take pictures while attending an event. The average computer using experience is more than 10 years and the average of computer usage is above 10 hours everyday. In this work, interviewees are asked open ended questions on how they handle "co-event" photos after the "co-event". Those questions are open ended to let them explain their thoughts. For example, (1) What do you usually take a picture with? Why? (2) How do you gather the "co-event" photos from others? Do you have any trouble? (3) How do you organize the gathered "co-event" photos? Do you have any trouble while browsing them? (4) Will you share your albums to your friends actively? How? (5) Will you actively browse your friends' online albums? The feedback is summarized as the life cycle of a "co-event" album into the following 5 stages.

Creating. While attending an event, most of them would take pictures with their friends, which can be the evidences to prove that they were being together at that time. They will also take pictures with scenes or objects that they are interested in. Some interviewees insist what their friends take may not be what they want, and what they capture can be represented as a visual story through their own view angles. They think that taking photos is not only for memory, but also for documentation.

Gathering. Interviewees may have their pictures taken by friends during the event, while the memory chip is left in their friends' cameras. Also, owing to their interest in the pictures that their friends took and what they missed in the same event, the interviewees often request their friends to send them the photos. If the file size is small, the study participants obtain the photos via e-mail or instant messenger. Otherwise, a portable disk, FTP or online storage service is used. However, gathering and distributing the photos becomes difficult if the "co-event" album has too many participates, explaining why the interviewees normally upload their photos to their online albums and check their friends' online albums to avoid disturbing their friends.

Organizing. The gathered photos are usually organized under one main folder named by the happened time, location, event name, or any of the combination. Their own photos will not be mixed with other photographers, though they prefer to mix them together while browsing. No one will mix the others' photos with their own, and will create new folders for the photos belonging to different photographers. Though they prefer to mix them together while browsing, the mixed photos may cause some browsing problems and the owners' information will be lost.

Browsing. Some interviewees browse the gathered photos with their own photos together. Mixed photos browsed in a "co-event" album are often mis-aligned since the camera clocks of the different contributors are normally unsynchronized. Besides, the interviewees often tend to skip the duplicated photos.

Sharing. 6 interviewees share their photos with friends actively, especially those attending the same event. Before sharing the photos, the interviewees normally filter out duplicated photos, as those of poor quality or personal ones. An online album is the most used sharing channel. Several interviewees also mentioned about the privacy issue, and they would like to let only certain people watch their albums.

Updating. To update the information, they usually browse the thumbnails and keywords through their friends' albums to find the interested photos. Most interviewees frequently check the online albums of familiar friends actively. The most often checked albums belong to the most familiar ones. Interviewees also express their interests in the uploaded albums related to the events they also attended. 2 interviewees even mentioned that they will browse the albums thoroughly, if their faces are tagged in the albums. However, finding uploaded photos may be difficult if the photos are taken by unfamiliar friends.

Based on the interviews, several area of improvement are identified to guide the proposed system design. For instance, individuals have difficulties in sharing, updating, gathering, and browsing "co-event" photos. Additionally, sharing all photos with everyone attending the same events is difficult. Moreover, gathering all others' photos is also hard and it is even harder to find them in the online albums (i.e., the problem of updating). Furthermore, aligning the gathered photos captured by different cameras is an important concern while browsing duplicated photos are also a problem.

IV. DESIGN

As mentioned in the previous section, the online albums' users are mostly interested in "co-event" photos and albums. The most important key factor affects their choices about to-be browsed albums is the relationship between the albums and them, such as whether they joined the events or not, the

relationship between the albums' owners and them, and the connectedness between the participants in the events and them, etc. However, there are few online album services provide a mechanism for them to share, update, gather, and browse them. The demand inspired us to design a suitable mechanism for "co-event" photos browsing and collecting web albums.

Based on the feedbacks from the prior user study, the following design guidelines are set before developing a "co-event" album viewing mechanism.

- **Linking and Merging Co-event Albums.** To make people easily share, find, and gather "co-event" photos, one efficient way is to link and merge all friends' albums together if they were captured at the same event. However, since the numbers of albums and photos are usually large, we need to further provide a good abstraction view and browsing mechanism to reduce viewers' burden as the following two guidelines.
- **Overviewing Linked Co-event Albums.** While providing an overview of the linked "co-event" albums, the relationship between the viewer and the album owners should be considered, since the relationship is the most significant factor to attract the viewer to browse. A good "co-event" album viewing mechanism should give viewers an overview of the numerous linked albums while considering the relationship. Since the relationship between an album's owner and a viewer is the most significant factor to attract the viewer to browse, the relationship issue should be considered in designing the "co-event" album overviewing mechanism.
- **Browsing Merged Co-event Albums.** The proposed "co-event" album browsing mechanism should deal the photo mis-alignment and duplication issues. As disclosed in our prior user study, people have problems while browsing the merged "co-event" albums due to the photo mis-alignment and duplication problems. Hence, the proposed "co-event" album browsing mechanism should provide a way to deal with these problems.
- **Efficient Sharing Management.** Considering the issue of utilities, the proposed design should also provide a management mechanism for albums' owners to easily edit their albums' profiles. As mentioned above, to decide whether viewing an album depends on the relationship information of the album and the viewer. Therefore, the edited information should be visualized to reveal the relationship information. Besides, in the prior user study, some users also care about the privacy issue, therefore, a basic privacy control should be considered.

Based on the design guidelines, two different views are designed. The *indexing view* provides the overview of the "co-event" and normal albums by a given social network. The *browsing view* focuses on the representation of photos in an album, especially those in the merged "co-event" albums.

A. Indexing as a Metro Map

A metro map is suitable for portraying abstract data for navigational purpose [5][6], in which an individual and an

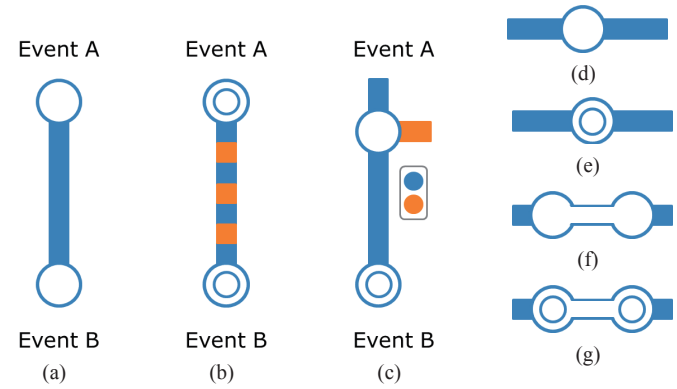

Fig. 2. (a) A *solid edge* refers to an individual having joined Event A and then Event B. (b) A *dash edge* refers to the same people group sequentially joined Event A and Event B. (c) An intersection with a traffic light symbol implies that several individuals get together into a certain event or leave for each other after it. (d) A *normal node* represents a single album. (e) A *joint node* represents a merged "co-event" album. (f) A *long-duration node* or (g) a *long-duration joint node* implies that the duration of the single or merged album is too long to fit the timeline's unit.

album are encoded as a track and a station (i.e., node) in the *indexing view*. Hence, people can know a friend's activities by traversing the corresponding track, or aware of that some friend have joined the specific event together by observing which tracks pass through that node. A "co-event" album can then be encoded as an "intersection" station (i.e., joint node), implying that several individuals join this event together; many tracks are thus linked together at this station. Consequently, the *indexing view* can provide an overview of the linked scattered online albums in social website(s). Visualization and interaction are described in details as follows.

Visualization. Three kinds of edges encode the change of the relationship as shown and explained in Fig. 2 (a)∼(c). Because human are limited in perceiving several colors simultaneously [22], a maximum of seven color hues [23] are available for users to highlight their interested friends and the remaining uninterested tracks are rendered with the gray color. For the nodes, shapes are used to encode album's types, as shown and explained in Fig. 2 (d)∼(g). If two albums have similar photo taken time and people, they will be merged as a "co-event" album. The indexing view is rendered as an orthogonal layout from left to right to follow the temporal order, since the grid layout can be easily understood [24] and

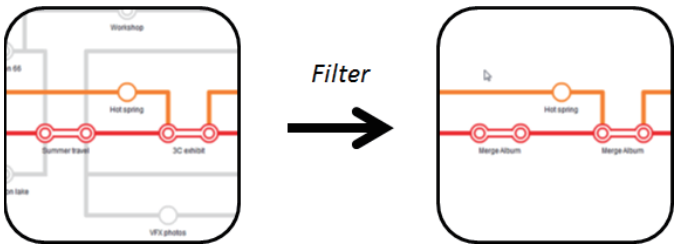

Fig. 3. While a viewer hovers at a merge node, the information about the composition of the merge node will be popped up.

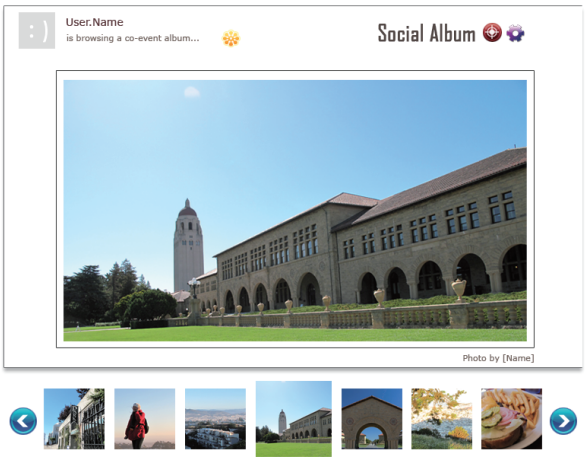

Fig. 4. User interface of the browsing view.

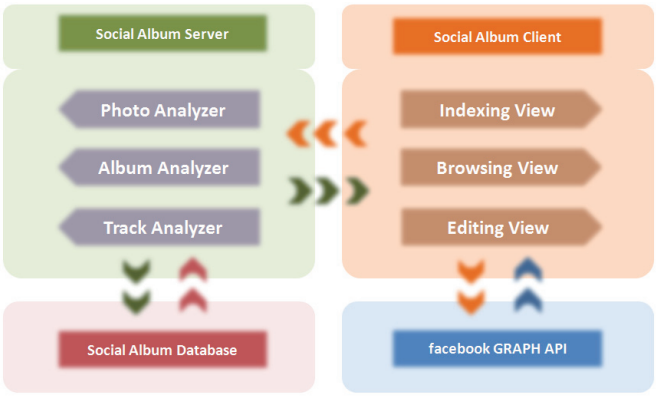

Fig. 5. *Social Album* system architecture and overview of the data flow.

can be rendered efficiently.

Interaction. To address the scalability issue, this work designs an interaction mechanism to filter out the uninterested tracks and reserve those desired tracks in a single view. Fig. 1 illustrates a popped up big circle containing each participant's album, which allows the viewer to easily switch among the albums belonging to the same event, while a merged album node is hovered. A specific reference track can be selected as a main track, which is always laid as a straight line. Nearby tracks of the main track are arranged according to the number of "co-events" to make the view besides the main track with abundant information. Therefore, viewers can browse the activities of other friends with a specific individual's activities as a chronicle.

B. Browsing Merged Albums

As described in the PRIOR USER STUDY section, the interviewees claim that they have duplicated photos and spend much effort in aligning the gathered photos. Hence, in the browsing view, photos in the merged "co-event" albums are aligned and grouped automatically according to their taken time and color similarity as the following methods.

Fig. 4 shows the browsing view while a user clicks a node in the indexing view. The center shows a photo which the viewer is browsing, and the bottom shows the photo thumbnails in this album. The stacked thumbnails refer to the grouping of similar photos. A viewer can click left and right keyboard buttons to browse the previous or next (grouped) photos, and click top or down keyboard buttons to browse the content inside a photo group. Though we provided a simple method to align and group the photos in the merged "co-event" albums automatically, the viewer still can modify the aligned and grouped results through an editing view like other photo management applications.

V. SYSTEM IMPLEMENTATION

To realize the concept design of *Social Album*, we chose facebook[3] as the implementation platform, because facebook right now is not only the largest photo sharing website, but also the largest social website.

A. Client Side Modules

The modules on the client side are responsible for visualization, interaction, and relaying required information. To represent the data, the parser on the client side will request the raw data from database and facebook, and then process the data into the predefined logical format. Users can interact with the information through two views, which are indexing view and browsing view. The detailed design for visualization and interaction have been mentioned in the previous DESIGN section, and the data is just processed according to the predefined rules. Nevertheless, the thumb rule of designing indexing and browsing is to make information compact in one view.

The editing view is just designed for users to easily complement the lost or insufficient information, like the happened duration and participants. Users can also issue the merge request or manage the merge request from their friends through the editing view. Because the result of indexing view and browsing view are dependent on these information, therefore, if any new album is imported, users will be led to the editing view while login. For further understanding users' long-term behaviors, the system logs users' behaviors automatically.

B. Server Side Modules

The back-end server is responsible for analyzing the raw data and relaying the required information from a back-end database. There are three analyzers, which are photo analyzer, album analyzer, and track analyzer. The photo analyzer will response for extracting low-level image features of each photo and grouping similar photos. The album analyzer is responsible for analyzing the similarities among the albums in the social network and providing recommendation. Besides, the module also deals with the merge requests to decide whether merging the related albums, and once the albums are determined to be merged, the photo playing sequence order will be calculated. About track analyzer, it analyzes the line intersection by the tag information, and put the most related

people close to each other to reduce the intersection. The detailed implementation and methods are illustrated in the following subsections.

1) Album Analyzer: There are three modules in Album Analyzer, which are album recommending module, album merging module, and merge checking module. The album recommending module is to find out potentially "co-event" albums in the social network. The album merging module is responsible for calculating the new displaying order among the merged albums. The merge checking module is to check whether the related album should be merged or not.

Aligning Merged Photos. The best way to align and group the photos from the "co-event" albums is to take their original taken time into account. However, photos captured at the same time by different cameras may have different taken time since the cameras are always not synchronized. Therefore, in our system, we use the color information to align and group the photos among the "co-event" albums. Nevertheless, though photos from different albums are merged together, the original playing sequence in each album should be kept. Therefore, if two albums, A and B, are going to be merged, we take one album with more photos as the reference (A) for the other (B), and first insert similar photos from B to their corresponding positions according to their color similarity, which is calculated by using Smith and Chang's method [25] due to its efficiency. For each photo, it only takes 1 ms. to calculate the required feature vectors on a notebook PC with an Intel Core 2 Due T9300 2.5GHz CPU. If any conflict happens, the majority rule is adopted. Then, the rest photos in B are inserted due to their relative time stamps comparing to the inserted photos. If there is no similar photo among A and B, other "co-event" albums will be merged first. If some albums have no similar photo in the merged album, they will be inserted uniformly according to their normalized time stamps.

2) Photo Analyzer: Photo Analyzer contains two modules, which are feature extracting module and photo grouping module. The low-level image features of each photo are extracted by feature extracting module, and based on the extracted feature vectors of each photo, similar photos will be grouped together by photo grouping module.

Grouping Similar Photos. Because people usually take photos with burst behavior, therefore, in an album, some photos might be similar and related [26], especially when we gathered and merged several friends' albums captured at the same event. Therefore, to save users' browsing time, grouping similar photos together is the most used method. To discriminate the similarity among the photos, the previous calculated feature vectors are compared by using L1 distance. Moreover, by considering the photo taken time as an essential clustering factor [27], only the adjacent and consecutive photos are grouped together.

3) Track Analyzer: In order to reduce the crossing of the tracks, if two people participated in the same events often, they will be put together or nearby. Instead of any global optimization method, we proposed an intuitive greedy algorithm due to efficiency issue of web implementation. The system will choose a track which has most events, and most intersected participants as a start point. Then, it will find the most related two tracks put by its two sides, and iteratively construct the global map. Although intimacy table is not globally optimized, it guarantees local optimization, and the result is still satisfying.

C. Limitation

Due to the limited space, the scale is the most limitation in our system. Usually, a user has hundred of friends on a social network website. However, with such amount information, it is impossible to show all of them on the limitd screen space. Therefore, a suitable interaction filtering mechanism might be a way to solve the problem. The other issue is the time scale issue. Right now, the unit of the timeline is one day. However, several events might be happened in one day, and cause the nodes overlapped. On the contrary, some people might upload albums by month, and the scale of the timeline will be too sparse for them. Therefore, a scalable and dynamic timeline might be one of the improving directions.

VI. EVALUATION

There are two main goals of *Social Album*, which are providing an overview of the linked albums based on users' social relationship and a mechanism to group similar photos while users browse the merged "co-event" albums. To evaluate the first goal of the proposed metro-map-like representation for the indexing view, we performed a qualitative user study to access the virtues of the design. On the contrary, to evaluate the grouped result for the browsing view, we perform a quantitative user study. The details of the user study are described below.

A. Qualitative User Study

Procedure. 6 participants (4 males + 2 females) were interviewed. All participants had online albums and social website accounts, and enjoyed taking photos while participating some events. They all have the habits to gather "co-event" photos from their friends after the events, and to browse their friends' uploaded online albums for updating their friends' recent information. The participants were first asked to browse the testing photos belonging to online albums of some individuals until they stopped spontaneously. The participants were then asked to browse the same data organized by the proposed *Social Album* system. After the participants stopped browsing, interviews were held with several open ended questions.

Results. While navigating through the indexing view, 4 of the participants commented that the metro-map-like indexing view allowed them to easily update the information for their friends and easily identify the "co-event" albums by different node visualizations. Moreover, half of the participants also claimed that they fell motivated to join those events in the future when discovering that their friends had attended such events. Some of the interviewees also stated that "co-event" photos were conversational topics while meeting friends attending those events.

1 participant mentioned that with this kind of user interface, it may be able to easily describe his friends' events, which is more like story telling. Because different types of nodes have different visualizations, the participants usually can easily point out the "co-event" albums. Moreover, on the user interface, if a user is tagged into an event, the track belongs to the user will also go through the album node. Therefore, the participants can follow the track to follow a specific friend's news much more easily. Due to the ease of following a track through the metro-map-like indexing view, the participants wanted an advanced feature to group the tracks together in order to trace the events of a certain group of individuals. The participants all appreciated the design of the filtering mechanism, which allows them to colorize the important tracks while graying out the uninterested ones. While browsing the merged albums in the browsing view, most of the interviewees appreciated the design by grouping similar photos together. Some participants even commented that grouping all similar photos together may be possible and they did not need to seriously consider the order of original photos. 1 participant suggested adding some thumbnails on the nodes in the indexing view, which allows users to know or preview the album contents.

B. Quantitative User Study

In this quantitative user study, we are going to prove two things. The first one is that merging photos from the same events but different albums will indeed increase users' understanding about the event. Second, grouping similar photos together by our simple method based on color similarity will not cause significant information loss.

Procedure. We recruited 22 participants (14 males + 8 females). For each participant, we let them perform the testing task three times with prepared three sets of photos. First, a participant was requested to browse a single album. Second, he or she was then requested to browse a merged album which contains the previous single album. The photos in the merged album are aligned and grouped. Third, the participant was requested to browse all albums without grouping. For each testing, participants will be examined with their understanding by some prepared questions. All questions are about the events in the photos they will see. For more robust testing, we performed the test three times with three different datasets.

Result. All participants found more events in the second testing than those in the first testing. Therefore, this result supports that though similar photos are grouped, the information in the merged album is still more than a single album. Comparing the second browsing experience with the third one, though the number of photos in the merged and grouped album is reduced, only 1 participant found one additional event in the third testing, and others cannot find any significant difference between the second and the third testings. Hence, it shows that grouping similar photos by our simple method based on color similarity will not cause any significant information loss, but the browsing time can be shortened. Therefore, by browsing the merged and grouped "co-event" albums in the browsing view, people can efficiently browse the photos without missing any significant information.

C. Discussion

Most of our user study participants like our metro-map-like indexing view. They felt interesting and novel about visualizing the relationship between the linked and merged albums. Moreover, they agreed no matter whether they were in the event or not, *Social Album* can help them to understand the whole event, especially to browse the "co-event" albums and photos becomes much more convenient and efficient than before. Half of the participants also claimed that when they found their friends attended some events, it could motivate them to join those events next time. Some of them also said that "co-event" photos would be the social topic when they meet their friends attended those events.

Besides, one of the most common feedbacks to our prototype design is the amount of information. Some participants felt that there are too much information in the indexing view even though they all agreed that the information is meaningful and important for them. They suggested us to propose a level-of-detail concept about it, so that viewers can zoom-in to see more carefully if they want to know more details; or zoom-out to just get the abstraction with limited information. Second, some participants also suggested to make people-and-path mapping much simpler, such as to add personal thumbnails instead of current color-people mapping.

In addition, the participants also suggested to have higher customization. They would like to have the capability to choose who's photos should be merged into their albums. Though it can be achieved by using our simple editing view, a more user-friendly mechanism is required. To make them more understand their friends, the participants also wanted a more talent system which can learn their social behaviors and operations automatically. For example, if a user often visited some friends' albums, then the system should rank the often visited friends' albums higher to make the tracks of these friends much closer to the user's track in the indexing view. Moreover, while performing the merging and grouping operations, the system can also takes the learned photo manipulations into account to hide or remove some look-bad photos automatically in the browsing view.

VII. CONCLUSIONS AND FUTURE WORK

This work presents a novel system, *Social Album*, by utilizing the existed social relationship data to link and merge individuals' online albums. The metro-map like design of the *indexing view* provides an overview of the linked albums, while the *browsing view* allows individuals to watch photos without mis-aligned and duplicated photos from merged albums. The result from the user study shows that the metro-map-like indexing view can efficiently present the overview of the linked albums to allow users easily tracing interested friends' albums. The evaluation result also shows that browsing the merged "co-event" albums can make people know more about the event, and grouping the photos in the merged "co-event"

albums can let people efficiently browse the merged albums in the browsing view without any information loss. From the feedbacks, the participants did not only appreciate the novel merged method, but also wanted higher customization.

Moreover, since *Social Album* is implemented on facebook[3], analyzing users' interaction logs on *Social Album* can further improve the browsing experience by adding intelligent customization features according to an individual's usage patterns. By learning users' online social behaviors and operations automatically, the system can be further improved to rank the often visited friends' albums higher and make the often visited friends' tracks closer to the user's track in the indexing view.

Nevertheless, *Social Album* by linking and merging people's online albums together based on their social relationship does not only provide a novel way to overview the relationship between the albums, but also provide an efficient browsing mechanism by grouping similar photos together to save users' brwowsing time.

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