PLUM: A Photograph Browser with a Layout-Upon-Maps Algorithm

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Abstract— **This paper presents "PLUM", a photograph browser that places clusters of photographs onto a map while drawing trajectories of photographers. PLUM is useful to look at photographs while observing their activities. PLUM firstly clusters photographs based on places and times, and places representative photographs of the clusters onto a map. PLUM shows all photographs in the specified cluster when a user interactively selects a representative photograph on the map. It features an algorithm to avoid overlap among photographs and trajectories on the map to realize their all-in-one display.**

Keywords-photograph browser, layout upon maps

I. INTRODUCTION

With the rapid spread of digital cameras, we have enormous digital images in recent years. On the other hand, it is a big burden for users to arrange such a large quantity of images. Actually, structures of images saved in their computers are often complicated. Therefore, automatic classification and effective visualization of large number of images are actively researched.

When a user looks at photographs on a computer, we may want to look at them based on the places where they are taken. In addition, it is convenient if we can observe them on a map, for example, we may want to know the activity of the photographer in the specific date from the photographs. There have been several software services which show photographs on a map at the positions specified by latitude and longitude; however, they cause many overlaps among photographs, or between a photograph and geographic information drawn on the map. Consequently, it is often difficult to understand the activity of the photographer.

On the basis of the above discussion, this paper presents a photograph browser "PLUM" (Photograph Layout Upon Maps). PLUM firstly applies a clustering algorithm for all photographs according to their places and times. PLUM then arranges representative photographs of the clusters on a map, while avoiding overlaps among photographs on the map to realize their all-in-one display. In addition, PLUM has two modes named "Long span mode" and "One day mode". "Long span mode" displays many photographs for a long term in a mass, while "One day mode" displays the trajectories of the photographer with photographs on a day. Users can freely switch the two modes along their use scenarios. We expect users can intuitively understand not only where photographs were taken but also activities of the

photographers. Also, we expect PLUM helps us to observe of the behavior pattern of the photographers.

II. RELATED WORK

There have been several famous commercial software for image management and browsing of personal photographs, such as Picasa [1] and iPhoto[2]. These systems support various functions to arrange and browse photographs based on time, place, and persons. Also, they support to produce on-line photograph albums synchronizing with servers. However, these systems remain some issues on browsing of large number of photographs. For example, they may cause heavy overlaps among photographs when they browse them on the geographical maps. Several recent studies including LifeLogViewer [3] also addressed on various photograph browsing; however, still they remain problems on browsing of large number of photographs.

Many studies on browsing large number of images have been also presented [4,5,6,7]. Some of these systems support functions to arrange and display images according to their places, times, and photographers. Some of them also support functions to arrange the images onto maps; however, they often cause many overlaps among images on the maps. This problem may prevent all-in-one display and operability.

MIAOW [8] is a photograph browser which overcomes the problem. MIAOW clusters photographs event-by-event based on their places and times. MIAOW arranges representative photographs of the events in a three-dimensional space where longitude corresponds to the X-axis, latitude corresponds to the Y-axis, and date and time correspond to the Z-axis. MIAOW displays all photographs belonging to an event along zoom operations. At the same time, MIAOW generates groups of persons taken in the photographs by calculating their co-occurrences in each event, and shows face images of the groups. MIAOW enables us to search for a lot of photographs intuitively by alternatively operating them.

PLUM looks somewhat similar to MIAOW since both systems place representative photographs of the events based on their geographic information. PLUM features the faster photograph layout algorithm which recalculates their positions while the interactive viewing operations, against photograph layout of MIAOW is static. Also, photograph layout algorithm featured by PLUM is specialized to display trajectory of photographers with the representative photographs.

III. Photograph Browsing by PLUM

This section presents technical components of PLUM. We suppose that all photographs browsed by PLUM have information of latitude, longitude, date and time.

A. Clustering

PLUM applies different implementation of clustering algorithms for "Long span mode" and "One day mode" respectively. Then, PLUM chooses representative photographs for each cluster.

For "Long span mode", PLUM simply applies a clustering algorithm to all photographs based on longitude and latitude.

For "One day mode", PLUM firstly generates clusters according to the days of the photographs. This paper calls the clusters "high-level clusters". Next, PLUM applies another clustering based on the following two conditions for each high-level cluster:

- If the difference of times between the $(i\text{-}1)$-th and i-th photographs is more than α, PLUM generates a new cluster for the i-th photograph.
- If the distance in the Mercator projection space between the i-th photographs and the center of the cluster of the $(i\text{-}1)$-th photograph is more than β, PLUM generates a new cluster for the i-th photograph.

Figure 1 shows the data structure applied for "One day mode". Though our current implementation of PLUM experimentally defines the values α and β, we would like to develop a technique to calculate optimal values of them in the future.
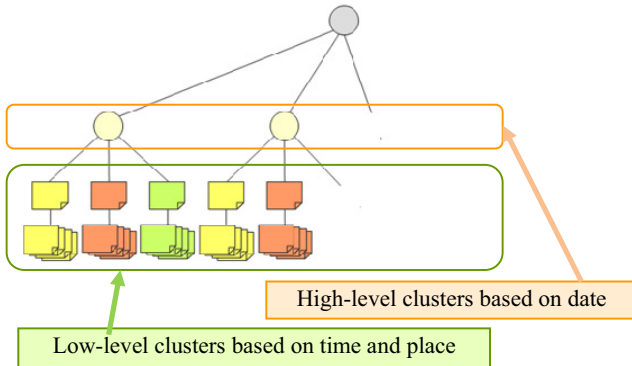

Figure 1. Two-level clustering for "One day mode"

B. Trajectories of a photographer in "One day mode"

PLUM draws trajectories of photographers as polygonal lines in "One day mode". As vertices of the trajectories, PLUM calculates the means of latitudes and longitudes of low-level clusters, and plots the means onto a map. This paper defines positions of these vertices as ideal positions of representative photographs of low-level clusters. Next, PLUM connects the vertices in the order of times of photographs, as red lines shown in Figure 1 red line. Our current implementation of PLUM treats them as trajectories of the photographers. We would like to incorporate GPS log to draw fine trajectories. The above function is only for "One day mode", not supported for "Long span mode".

C. Placement of representative images

PLUM displays representative photographs near their ideal positions with the trajectories. PLUM calculates positions of representative photographs while it avoids overlaps among photographs or between a photograph and a trajectory. Section III-D describes the algorithm to calculate the positions of representative photographs. Furthermore, it displays links between ideal positions and the centers of representative photographs to indicate the original positions of representative photographs. In addition, PLUM calculates the positions of photographs whenever scaling or translation is operated by users. Our current implementation of the position calculation function may suddenly move photographs while their scaling or translation operations, and may confuse the users. We experimentally solved this problem by calculating the middle point between the current placement position and its original ideal position as the tentative ideal position of a photograph, and attempts to place the photograph around the tentative ideal position.

D. Position calculation for representative photographs

Our implementation of position calculation method consists of 4 steps as shown in Figure 2. First, it divides a window space in state of lattice and draws a trajectory. Second, it excludes the rectangular domains the trajectory passes from candidates of positions, as yellow domains shown in Figure 2(2). Third, it searches for empty rectangular regions, as 2x2 red domains shown in Figure 2(3). It attempts find the empty regions as near as possible to the tentative ideal positions. Finally, it generates links between the centers of the photographs and the original ideal positions as straight segments, as shown in Figure 2(4).
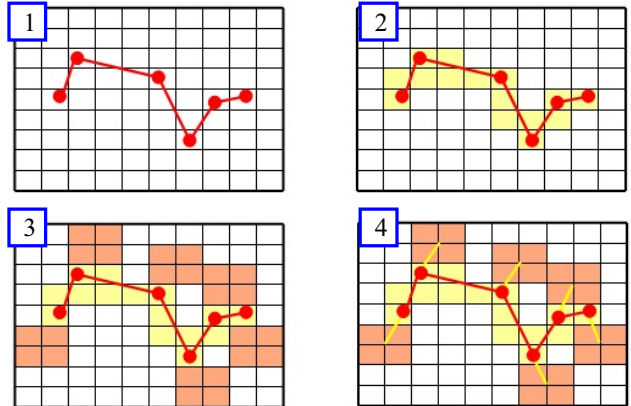

Figure 2. Position calculation and display of representative photographs

IV. Example

This section introduces an example of photograph browsing using PLUM. The photograph set used in our experiment

consists of 1,534 pieces taken in one month, extracted from photographs taken by a certain user as life log everyday (about 160,000 pieces). Positions of photographs were recorded into the EXIF domain of JPEG by Sony GPS-CS3.

Our implementation of PLUM firstly displays photographs in "Long span mode". In this mode, PLUM displays a map in the left of the window as a background image, and overlays representative photographs. Figure 3 shows the initial display of "Long span mode". It initially adjusts the zoom of the world map so that all the representative photographs are displayed in the left of the window. The representative photographs never overlap on the map, and therefore users can understand the existence of all the events of the photograph owner. The window also features GUI widgets on a tab displayed in the right of the window.
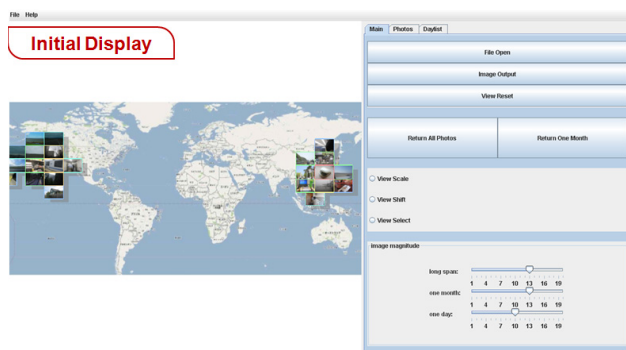

Figure 3.   Initial display of "Long term mode". It displays all the representative photographs by adjusting the zoom of the world map.

Figure 4 shows an close up to the eastern Asia in the "Long term mode". When a user selects a representative photograph by the click operation, PLUM displays all the photographs of the cluster corresponding to the clicked representative photograph on the "Photo tab" displayed in the right of the window. Remark that the layout of representative photograph is rearranged after the zooming up, and again, we can observe all the representative photographs since they never overlap.

Figure 5 shows another close up view to the center of Japan. The "Day List tab" shows the list of days that one or more photographs are taken in the clusters displayed in the left of the window. Users can select a particular day on the "Day List tab" and then move into "One day mode".

Figure 6 shows an example of "One day mode". This mode displays a brief trajectory of the photograph owner by connecting the ideal positions of the low-level clusters. The segments connecting them are colored according to the timestamps of the photographs in the clusters. At the same time, PLUM generates a new "Day Photo tab" which displays all the photograph of the day. When a user selects a representative photograph by the click operation, PLUM displays red borders around photographs in the cluster corresponding to the clicked representative photograph. This

function assists to discover particular photographs taken at the particular places on the selected day.

Figure 4.   The "Photo tab" shows all the photographs in the clusters corresponding to the clicked representative photograph. Remark that the layout of representive photograph is rearranged after the zooming up.
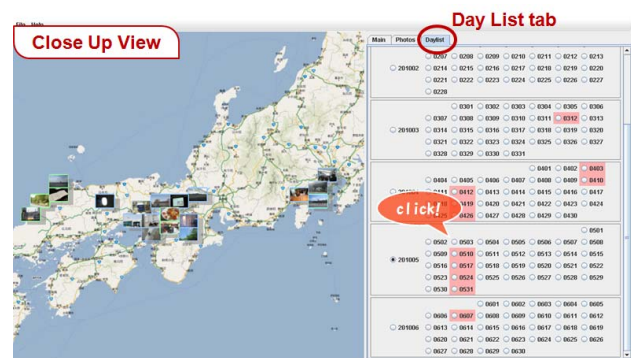

Figure 5.   "Day List tab" displays the list of days that one or more photographs are taken. Users can select a particular day and move into "One day mode".
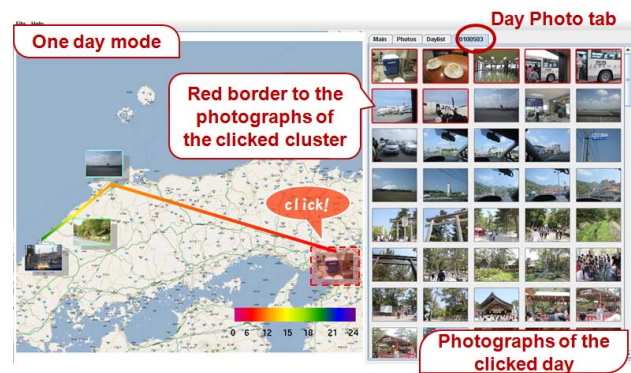

Figure 6.   "One day mode" displays the trajectory as well as representative photographs in the left of the window. "Day Photo tab" displays all the photographs taken on the day. Red borders are displayed around the photographs taken at the place of the clicked representative photograph.

As shown in the above figures, PLUM provides a mechanism of photograph exploration based on click operations of representative photographs displayed on the

map. Users can freely look at the map, and touch to the photographs placed at the interested places. PLUM rearranges the positions of representative photographs without any overlaps after every viewing operations, thanks to the fast placement algorithm, and therefore users can click all the displayed representative photographs anytime. We believe PLUM provides a new paradigm to explore personal photograph collections.

V. CONCLUSION

This paper presented PLUM, a photograph browser which places representative photographs onto geographic maps. PLUM features two modes "Long term mode" and "One day mode"; the former mode is suitable to find places where the photograph owners have visited, while the latter mode is suitable to trace their trajectories of particular days. PLUM is convenient to overview the events of the photograph owners, and observe their movements.

Following are our potential future issues:

GPS log consumption for trajectory display: Our current implementation connects the ideal positions of low-level clusters to briefly represent the trajectory of photograph owners. We would like to extend the implementation to read the GPS logs and display more detailed trajectories. It is useful to observe and analyze the movements of the photograph owners.

Improvement of representative photograph selection: We received various suggestions regarding representative photograph selection results, during we asked our friends to play with PLUM. Some of them suggested to select photographs which take landmarks or other famous architectures. Some of others suggested to select one of the photographs which are similarly taken in a short time. Also, we would like to test if famous general image selection techniques such as VisualRank [9] are also effective for the representative selection of PLUM.

Improvement of photograph layout algorithm: While PLUM does not cause overlaps among the photograph, it may hide terrain information or names of places. We are afraid it may frustrate the understanding of geographic information of displayed photographs. We would like to solve this problem by improving the photograph layout algorithm. For example, NecklaceMaps [10] displays labels around the focused regions without hiding geographic information. We think such techniques can solve this problem.

Web service based map display: Our current implementation just displays still images of captured maps as background. Of course it should be better to implement this browser on the Web-based maps such as "Google map", because these Web services dynamically provide adequate resolutions of map images.

Scalability: The dataset used in Section IV contains 1,354 photographs taken in a month. The owner actually stores over 160,000 photographs; however, we have not yet tested with such large number of photographs. We may need to improve the implementation to deal with such large photograph collections, by developing effective memory management, storage access, and a faster photograph layout algorithm.

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