Personal Photo Browser that can Classify Photos by Participants and Situations

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ABSTRACT
This paper demonstrates a photo browser which rearranges photos referring to the persons who were close to the photographer when the photos were taken by consulting Bluetooth device detection information. Most of Bluetooth devices accompany their owners. Each photo is tagged with Bluetooth device-IDs which were detected around the moment when it was taken. Employing the tag information, the system classifies the user's photo archive into a layered cluster tree in terms of tag similarity, and shows its user the photos of her-selected cluster on either a map or timelines.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

General terms: Design, Human Factors

Keywords: Life log, Bluetooth, tagging, digital photo browser.

INTRODUCTION
With the wide spread of digital cameras and camera phones, we all have had a huge personal photo archives with tiny costs. Methods for browsing/retrieving photos in such a huge archive are desired. A basic method is to sort by timestamps of the photos and/or to group photos with selectable time scales such as day, week or month. Another method is to place photos on a map where each was taken. These methods are simple and concrete but inapplicable to huge archives. Gomi et al.[2] presented a photo browser which was based on location, time and person detected by face recognition. The method, however, requires faces appearing in photos and thus only commemorative photos can be clustered. Although both Nair et al. [5] and Monaghan et al. [4] proposed photo sharing among multiple users by aggregating the Bluetooth presence information collected from them, they did not give interaction methods but proposed only sharing frameworks. Hui et al.[3] clusters human relations by sensing Bluetooth and Wi-Fi, but they didn't give a concrete application.

Our idea is in the following:

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1. The system clusters photos by *context*, i.e., persons who were close to the user when she took the photos, by referring to Bluetooth device detection log, and
2. shows her the clusters and their structures by three view modes, i.e., Graph Network, Map, and Timeline View.
3. She browses in her photo archive by switching among the three views and retrieves/finds photo(s) by exploring up/down the layered cluster tree and viewing the photos which belong to the cluster she selected.

Bluetooth equipped devices, e.g., cellphones or PDAs, have been ubiquitous in everyday environment, and are identifiable using their MAC addresses as unique IDs. In addition, many of these devices are discoverable from other devices in a communication range. The user takes photos while the system logs discoverable wireless devices as the tag for clustering photos. Our system rearranges photos by participants/situations identified from the detection log in addition to locations and timeline.

TAGGING DEVICE DETECTION LOGS
The system tags each photo with Bluetooth devices' unique IDs by the moment each device is detected. The photographer carries not only her camera but also a PDA or a slate PC for logging neighboring devices once/twice a minute (depends on logger device capabilities). The logger software records the information of discoverable wireless devices that consists of the moment when the device was detected, its MAC address and name (SSID). The logger device is also configured to be discovered from other photographers. Many mobile gadgets such as PC and PDA equip Bluetooth functions and many of them are configured as discoverable. Almost all mobile phones accompany their owners, so they are good sources for grouping photos which are taken together with the owners.

The system correlates obtained log data with photos by their time-stamps, i.e., tags each photo with device-IDs within the moment it was taken before and after 5 minutes. The tag of a photo is the set of Bluetooth device-IDs correlated to it in other words. The system constructs a huge weighted graph structure, where each node represents one photo and each edge represents correlation between two photos, and clusters the graph into clusters of correlated photos by the following process:

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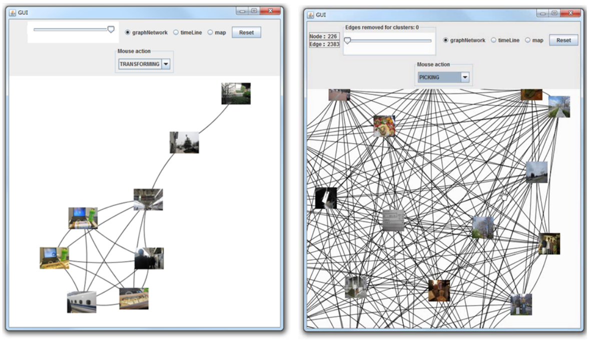

Figure 1: Snapshots of the Graph Network View.

1. The system adds an edge between every pair of nodes (photos) in the archive, if the tags of the nodes has intersection. Each edge is weighted with Jaccard distance between the tags of end-nodes.
2. The graph is clustered by Girvan-Newman algorithm[6]. The clusters are layered by applying multiple "betweeness" thresholds of the algorithm.
3. The system applies PageRank algorithm[1] to each cluster on each layer. The node with the highest PageRank is selected as the representative image of the cluster.

IMPLEMENTATION

The system is implemented in Java using Swing library, JUNG framework for Graph calculation and visualization, and Google Static Maps API for map-based operations.

Graph Network View

The *Graph Network View* is the primary view mode of the system as shown in Figure 1. In the initial state of the system (Figure 1 left), clusters of the most abstract layer and their correlations are displayed. Each thumbnail corresponds to a cluster and settled by Fruchterman-Reingold model, a force-based graph drawing algorithm. The user can 1) switch to another view by selecting one of radio buttons, 2) jump into a cluster of more detailed layer by clicking a thumbnail, 3) or climb back layers by manipulating the slide-bar. At the bottom layer each thumbnail corresponds to a photo (Figure 1 right) and she can find correlations among the photos.

Map View and Timeline View

Although the *Map View* displays the same structure with the Graph View, i.e., each thumbnail corresponds to either a cluster or a photo depending on the selected cluster, the coordinates of the thumbnail is the map location where it is taken (Figure 2 left). Certain community members, e.g., SIG-conference participants, tend to meet in many places and photos which are taken while participating the meetings tend to settled with certain distance on the conventional map-faced photo browsers. Using our system, however, she can find the correlation by seeing the edges in this view.

The *Timeline View* displays photos of the selected period of time, i.e., year, month, week, day, in either of the whole archive or the selected cluster in order of their timestamps. As shown in Figure 2 (right), each vertical red line corresponds to a photo and the user can see the thumbnail by moving the mouse cursor over the red line.

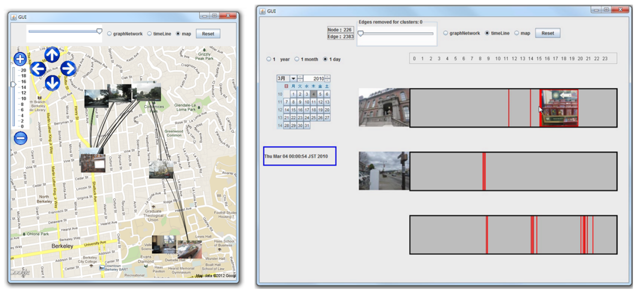

Figure 2: Map View (left) and Timeline View (right).

Table 1: Scale of data and photo archive of subject 1.

	Bluetooth ID		Wi-Fi ID		
Year	# unique	# record	# unique	# record	# photo
2009 (Apr.-)	34,604	1,078,067	8,523	838,951	4,563
2010	34,063	1,325,123	33,659	2,878,434	6,125
2011	17,356	1,386,228	39,771	1,587,977	7,743

CONCLUDING REMARKS

We have proposed and implemented a photo browser which rearranges photos referring to the persons who were close to the photographer when the photos are taken and incorporates conventional browsing interfaces, i.e., map and timeline. Three subjects have been pooling neighboring Bluetooth and Wi-Fi device-IDs in their everyday lives for more than a year. One of them started pooling in Apr. 2009 and the scale of the archive is summarized in Table 1.

Table 1 shows the number of detected unique Bluetooth devices are decreasing, because smartphones, which are discoverable only while they are manually set to discovery mode, are rapidly spreading and conventional cellphones, which are generally always discoverable, e.g., Blackberries, are disappearing. On the other hand, Table 1 indicates that mobile Wi-Fi access points including smartphones with tethering functions are quickly increasing. We are currently working on additionally applying the system to Wi-Fi detection log.

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