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TagNSearch: Searching and Navigating Geo-referenced Collections of Photographs*

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Abstract. TagNSearch is a map-based tool for searching and browsing geo-tagged photographs based on their associated tags. Using Flickr as the dataset, TagNSearch returns, for a given query, photographs clustered by locations, and summarizes each cluster of photographs by cluster-specific tags. A map-based interface is also provided to help users better search, navigate and browse photographs and their clusters. A qualitative evaluation comparing TagNSearch and an existing tag search support in Flickr was also conducted. The task involved finding locations associated with a set of photographs. Participants were found to perform this task better using TagNSearch than Flickr.

Keywords: Social tagging, TagNSearch, clustering, Flickr, geo-tagged photographs.

1 Introduction

The Web has evolved from an unidirectional information repository where access to information is the main focus, to a platform for collaboration in which content is generated and shared among users. As this new avenue for content-generation becomes increasingly popular, the resulting information explosion requires new techniques to manage, search and access such content [6]. For example, Flickr has gained much popularity among users who provide metadata to their uploaded photographs including titles, descriptions, and tags [3]. A tag is a relevant keyword associated with a photograph by the author or possibly other user, to describe the photograph. This metadata may also be used for accessing the photographs.

Access to photographs is typically accomplished using one of three main methods [14, 19]. The first is *keyword-based search* which is the most common way for

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finding information on the Web [13]. The second method is via a *tag cloud* which displays the tags alphabetically with different font sizes and/or colors depending on popularity. Tag clouds help in accessing documents through filtering, by retrieving documents associated with a selected tag [1]. The third method is by visualizing the geo-tagged photographs using a *map-based interface* [7]. Here, photographs are assigned to specific locations on a map, and users navigate the map to access them. However, as the number of geo-tagged photographs becomes very large, users may not be able to access them effectively because there are problems with each of the above approaches. Examples include synonymy and ambiguity where different tags have similar meanings, or when a tag has several meanings. A search system which simply matches keywords may not find the right photographs users want. Further, users may also find it difficult to locate photographs on a map due to the large number of results [16]. A tag cloud view alone may also not be adequate as it has the same problems as keyword-based search (synonymy and ambiguity) [8].

In this paper, we attempt to address the problems of accessing geo-tagged photographs through TagNSearch, a system which integrates the three methods discussed above. First, search results are clustered according to the zoom level set by users of the map-based interface provided my TagNSearch. Each cluster itself will have a tag cloud which summarizes the content of the photographs belonging to that cluster. Users can narrow their search in the cluster by selecting a tag if needed. To help users make sense of their search results, clusters are presented on the map with other supporting information such as the country where the cluster is located, the number of photographs within the cluster, the number of photograph contributors in the cluster, and so on. Our dataset is derived from Flickr.

This paper makes the following contributions:

1. We introduce a cluster-based approach to present the search results of geo-tagged items: nearby items are grouped into clusters, and each cluster contains information of the items it contains.
2. We provide a method of searching using keyword queries and tag cloud visualization. Specifically, the tags within the tag cloud are used not only to summarize the content in a cluster, but also used for narrowing a search.
3. We conduct a qualitative evaluation of our approach and demonstrate its effectiveness when compared to an existing map-based search system supported by Flickr.

The remaining sections of this paper are structured as follows. Section 2 provides an overview of the related work. Section 3 introduces the architecture of TagNSearch. Section 4 presents graphical user interface. In Section 5, an evaluation of the system is discussed, while Section 6 summarizes this work.

2 Related Work

We review to recent efforts for the visualization and retrieval of annotated/tagged photographs. These are TagMaps - World Explorer (referred to as World Explorer henceforth) and Flickr. In World Explorer [17], tags associated with geo-tagged photographs derived from Flickr are analyzed and displayed in a map-based visualization

tool. The system extracts representative tags for an area based on the photographs' tags. First, the set of photographs is clustered using their geographical locations. Next, the tags in each cluster are scored using a modified TF-IDF scheme that assigns a higher score to tags that have a higher frequency within a cluster compared to others in the area under consideration [8]. Each representative tag on the map (primary tag) has a subset of tags (secondary tags) that serve as a context for the user to interact with the system. The secondary tags are only displayed when users mouse over the primary tags. World Explorer supports searching only for known landmarks. For example, users can search for a tag such as "Singapore", and "London". Unexpected results may be returned for non location-based search queries like "sunset" and "airport". World Explorer displays photographs on a side panel but the photographs are overlapping making browsing of large result sets difficult.

Similar to our work, Flickr considers both patterns and distributions of tags associated with geo-tagged photographs, and uses them to generate tag cloud on a world map. When users select a tag, photographs and other popular tags (if available) will be shown. However, this tag cloud contains the tags of all the geo-tagged photographs in Flickr, and does not change in response to the type of search or a change in the view of the map (e.g. zoom level, displayable map boundary, etc).

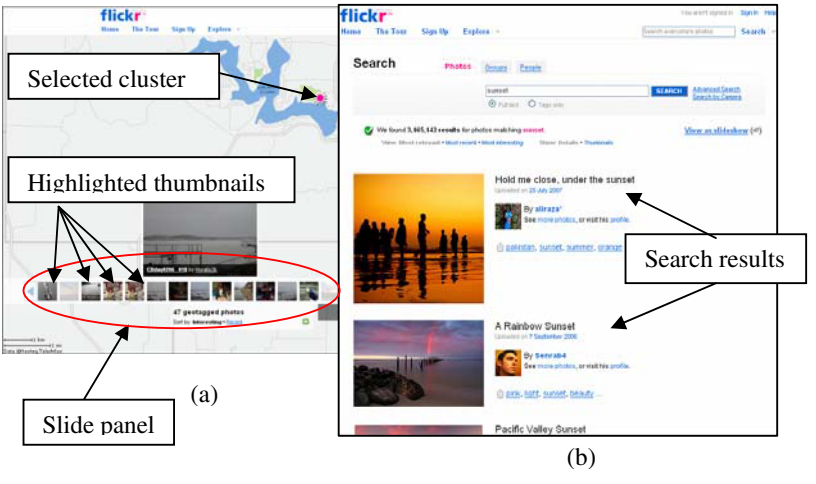

Fig. 1. Searching in Flickr: (a) Map search, (b) regular search

For photograph searching, Flickr supports two types of search. The first one (http://www.flickr.com/map/) supports a map-based interface in which search results are displayed on a map. Photographs of the same latitude and longitude are grouped into one cluster. However, Flickr does not show photographs belonging to each cluster separately. Instead, it has a *slide panel* to display all the photographs returned by search. Each *slide* contains around 20 photograph thumbnails and users have to navigate to the next or previous slide in the panel to view the photographs. When a cluster is clicked, Flickr highlights the photographs which belong to that cluster among all the photographs displayed in the current slide of slide panel. (see Fig. 1a). However,

the cluster may contain other photographs which may not be presented in the current slide panel. Hence users may not be able to see all the photographs actually belonging to that cluster. The second search engine (http://www.flickr.com/search) is a regular keyword search. Instead of displaying the photographs on the map, Flickr lists them sequentially across multiple search results pages (see Fig. 1b). In this case, there is no concept of a cluster or a tag cloud

Recognizing these limitations, TagNSearch attempts to improve on World Explorer and the Flickr map-based search by introducing the idea of clustering and tag cloud support to better facilitate search and navigation.

In addition, the popularity of tagging systems [3] has led to the emergence of a number of methods for presenting tags to users besides map-based visualizations. There are several studies about tag cloud presentation. For example, [18] presents a map of tags which shows these tags as distributed nodes on a 2-dimensional plane, where the edges represent the similarity relationships among tags. Bielenberg and Zacher [1] show tag clouds in a circular form, where the distance from a tag to the center and its font size represents the importance of the tag while [8] visualize tags temporally. Further, there have been research on evaluating the effectiveness of the use of tag clouds. Rivadeneira et al [15] conducted an evaluation of tag clouds for impression formation while [10] investigated the effect of different approaches for presenting tags such as alphabetization, font size, and position of tags.

3 The TagNSearch Architecture

The TagNSearch architecture as shown in Fig. 2. It consists of a geo-tagged photograph database, and modules for search, clustering, tag cloud generation and visualization. The dataset is derived from Flickr and it contains 197,391 geo-tagged photographs stored in a MySQL database. Each photograph is represented by a tuple consisting of a photograph ID, coordinates of the location from where the photograph was taken (latitude, longitude), owner name, title, photograph URL on Flickr, and user-generated tags. The user interface captures the keywords entered by users and passes it to keyword search module. From here, an error checking is carried on the keywords and a query is generated to retrieve data from database. The data then is passed to clustering module and tag cloud generation module.

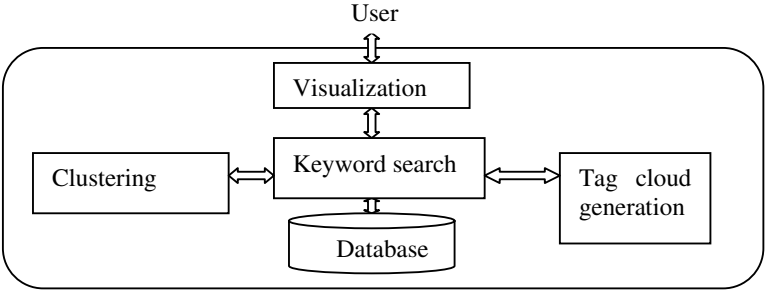

Fig. 2. TagNSearch architecture

3.1 Clustering Algorithm

The clustering module generates an optimum number of clusters of photographs for display. The search terms *s* and the current zoom level *zm* of the map (which ranges from 0-18 as defined by Google Maps) are input parameters to the clustering algorithm. The algorithm is similar to the approach adopted by [4]:

- Step 1: extract a list of photographs which are tagged with keyword *s*. These photographs are named *Ps*.
- Step 2: iterate through *Ps*. We treat each photograph as an individual cluster and attempt to merge each photograph with existing clusters based on centroid distance. At the end of the iteration, we obtain a set of clusters.
- Step 2-1: apply the formula 2^{5-zm} to obtain the maximum allowable distance between two centroids. This approximation results in a cluster with the diameter of 1 cm on the screen with a resolution of 1024 x 768 (which is a common resolution for PCs) regardless of the current zoom level. Once a photograph is merged with an existing cluster, the centroid is updated based on the number of existing photographs in that cluster and the new photograph's distance from the centroid. We use the following formula to calculate the new centroid latitude. The same formula is used for calculating the centroid longitude:
  NewCL=OldCL + ((NewPL - OldCL) / (NumUser+1))
  Where: NewCL= New centroid's latitude
  OldCL = Old centroid's latitude
  NewPL = New photograph's latitude
  NumUser= Number of existing users in the centroid.
  The calculation of the centriod takes into account the number of users, and not the number of photographs. This approach helps to avoid bias if there are many photographs belonging to one user in the same cluster.
- Step 2-2: if the photograph does not belong to an existing cluster, it will form a new cluster.

3.2 Tag Cloud Generation

The tag cloud generation module is responsible for presenting the tags used in a photograph cluster using a tag cloud. Here, we record the number of occurrences of each tag in the cluster. Based on these occurrences, the font size of each tag is generated by normalizing the frequencies of tag occurrences using:

TagSize = 2.5 * (TagFreq – MinSize) / (MaxSize-MinSize)
Where: TagSize = the font size of particular tag in a cluster
TagFreq = number of photos in the cluster which contain the tag
MaxSize= Maximum font size desirable on user screen
MinSize= Minimum font size desirable on user screen

To avoid displaying the tag cloud with too many font sizes which can be confusing, we assign the size of each tag by ranges. For example, if TagSize is in [0.7,1) we assign a value of 1 to it. If TagSize is in [1,1.2) we assign 1.2, and so on.

4 Visualization

Fig. 3 shows the TagNSearch user interface which is a mash-up using Google Maps and our dataset of Flickr photographs. .The design is made simple with an input box at the top-left corner and the search results are located under it. The top-right of the page is a place holder for displaying thumbnails of photographs in a selected cluster.

To search, users input their queries and a list of clusters is returned in the Search Results area. Sort criteria for each cluster include Country Name, Number of contributors and Number of photographs. By sorting clusters of photographs by Country Name, users can quickly navigate to clusters located in a particular country. Sorting by Number of Photos provides users the most dense clusters first while sorting by Contributors lists clusters which contain more prolific contributors.

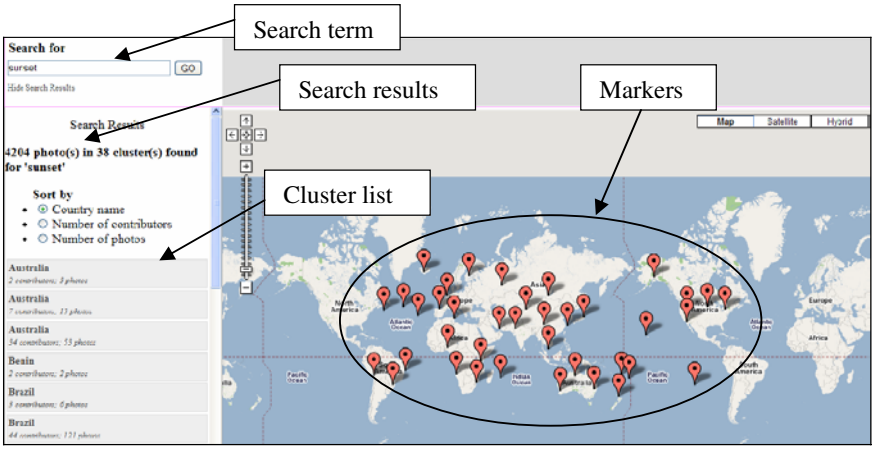

Fig. 3. TagNSearch search results

For each cluster in the search results list, a balloon marker is displayed on the map with the coordinators (latitude and longitude) calculated above (see Section 0). When a cluster in the search results list or its corresponding marker on the map is clicked, users will see its photograph thumbnails displayed on top of the page. At the same time, a tag cloud is also displayed right above the marker. The thumbnails list and tag cloud contain important information about the cluster. The tag cloud shows the country name, number of contributors, number of photographs, and location. The thumbnails give users a quick preview of the photographs within the cluster. Once a thumbnail is selected, its full image is displayed together with its title, owner name and all its tags. If the user clicks on this image, its corresponding page on Flickr will be opened. Users can easily navigate photographs in the thumbnail list using the Previous and Next buttons of the list. A complete set of the cluster's photographs can also be displayed in a separate Web page.

To support searching, the tag cloud (see Fig. 4) not only provides an overview of the tags in the cluster but also allows users narrow a search. Specifically, when a tag is selected, the system performs a new search by combining the current search terms

and the selected tag. This may also be considered as a form of filtering, which returns only photographs containing the selected tags.

4.1 Clusters

An important component of our user interface is the clustering of photographs. Compared to Flickr's approach, TagNSearch separates and presents photographs in their respective clusters. It displays thumbnails on top of the page whenever users click on a cluster or its corresponding map marker (see Fig. 4). These thumbnails and their photographs can be browsed easily as discussed. By displaying all photographs in each cluster separately, TagNSearch facilitates search and navigation by giving users the ability to access sets of photographs organized by clusters.

The second advantage of our cluster approach over Flickr is that we provide auto-panning of the map to the cluster marker's position when users click on that cluster in the cluster list (see Fig. 4). In Flickr, users cannot do this because the original map layout stays the same regardless of which photographs or cluster users click on. Put differently, users will not be aware of the existence of other clusters if these are not within the current view port of the map (see Fig. 1a).

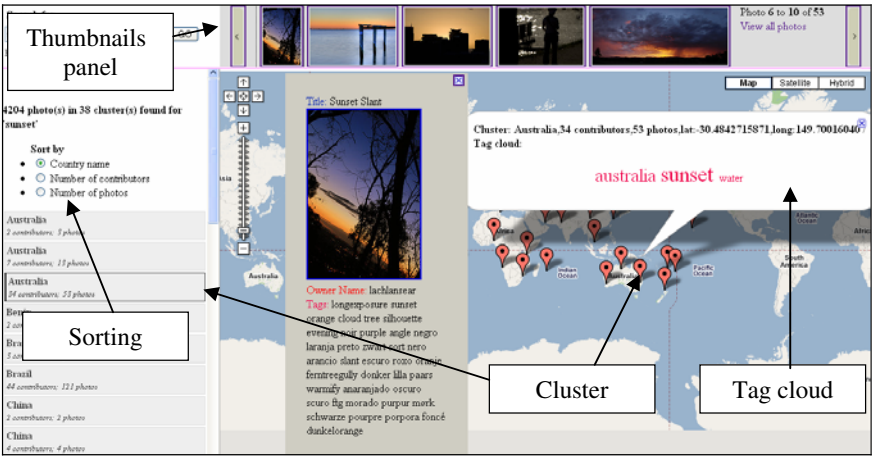

Fig. 4. TagNSearch clusters

The third issue is the definition of "cluster" itself. In Flickr, a cluster is a group of photographs in the search results with the **exact** latitude and longitude. However, when users contribute their photographs, these may be associated with slightly different latitudes and longitudes. This may lead to the problem that many similar photographs in a nearby location are separated into various clusters, overloading users with too many small clusters. In our work, we define a "cluster" as a group of nearby photographs (see Section 0), alleviating the cluster overload problem.

The fourth difference also originates from the "nearby" concept in the definition of our cluster. Since "nearby" has a flexible meaning, the distance between nearby photographs is changed when the zoom levels are different. Thus, users may have an a

broad overview of the search results by zooming out, and view more detailed clusters by zooming in. Put differently, the higher zoom level, the shorter the distance between nearby photographs, and the more specific the clusters become.

4.2 Tag Cloud View

Besides the convenience of using clusters to group photographs, our system also provides a tag cloud over each cluster, which is not included in Flickr. While World Explorer also has a similar tag cloud over a location, it does not have the concept of a "cluster". Instead, the system simply retrieves all the photographs in the bounded area to the generate tag cloud. This leads to the problem that users cannot restrict the topic of the tag cloud. When the map is panned, the area within the map boundary is also changed, and another tag cloud corresponding to this area is generated. This new tag cloud may thus not correspond to the original search. In contrast, the tag cloud of a cluster in TagNSearch depends only on the set of photographs of that cluster. For the same search and zoom level, this set of photographs is fixed. Therefore the tag cloud is not changed during map navigation.

5 Evaluation

We conducted a pilot evaluation to compare TagNSearch's and Flickr's usefulness and usability. The former was accomplished through two experimental tasks while the latter used the heuristic evaluation approach [14], a useful technique for examining usability problems in a user interface design. It involves examining the interface and judging its compliance with recognized usability principles. We chose Nielsen's 10 usability heuristics [15] for our evaluation.

5.1 Experimental Setup

The goal of the experiment was to compare the strengths and weaknesses of TagNSearch with Flickr, and to determine if TagNSearch can help users find correct locations associated with their photographs, and suggest relevant tags for that photograph. World Explorer was not included because in a pilot test, participants did not seem able to complete our experimental tasks.

Sixteen volunteers were recruited. All of them were familiar with the media sharing web sites and the concept of tagging. However, they had different levels of searching skills. Participants were first briefed about TagNSearch and the idea of searching for locations using tags. After that, half of them were randomly assigned to use Flickr while the rest used TagNSearch to perform the experimental tasks.

From our dataset, we picked 5 photographs with the content related to an arbitrary location. We removed all the obvious clues in the photographs' record that could reveal the photograph's location, and also dropped the tags. Only the photographs with their modified descriptions were given to the participants. The photographs were chosen so that some of them were easy to recognize places while others were more difficult. Each participant used a given system to perform 2 tasks: (A) Find the location of the given photographs by searching for tags; and (B) Find relevant tags from other photographs to tag the given photographs.

To complete the first task, participants needed to look through the photograph and its description to think of a related tag. They would then use the tag as a keyword to search for photographs containing that tag. Once they found similar photographs, they could infer the location of the given photograph. The second task typically depended on the success of the first task. If similar photographs are found, participants can look at their tags as suggestions to tag the given photograph. Each time a participant performed a search by clicking on the Search button (or clicking on a tag in a tag cloud when using TagNSearch), we recorded it as one query. The number of queries used will be considered as one aspect of the effectiveness of the system.

After completion of the two tasks, participants completed a questionnaire to record the number of queries used for each photograph, and rate the conformance of the system they used according to the 10 usability heuristics on a scale of 1 (low conformance) to 5 (high conformance). They were also asked to provide qualitative feedback on the respective systems.

5.2 Results and Discussion

Table 1 compares the effectiveness of Flickr and TagNSearch. The Participants Succeeded column shows the percentage of participants who found the correct location for the photographs, while the Queries column is the mean number of queries executed until the location was found or until participants gave up. As shown, the first three photographs are easy to recognize (e.g. well-known building or scene) while the last two were more difficult. In Table 1, TagNSearch performs better than Flickr in both percentage of participants succeeding and the number of queries made for each photograph. TagNSearch was somewhat better at helping users to identify the easy photographs but when the locations were not well-known, TagNSearch was significantly better in helping users complete the experimental tasks than Flickr. The main reason is that TagNSearch provides useful information of individual clusters to help users narrow the results from a large set of photographs in the database.

Once the location of a photograph was found, participants looked for appropriate tags to assign to the photograph. With TagNSearch, tags of all photographs in a cluster are easily seen through a tag cloud. Hence when participants found the location, they also obtained a list of tags, and most of them could quickly select proper tags to assign to the photograph. For participants who used Flickr, they seemed to have difficulty with the task. The reason is that, even though they found similar photographs, these photographs may not contain appropriate tags. Without a tag could, participants had to repeatedly check other photographs to complete the task. Thus even though participants could use both systems to find appropriate tags for photographs, it appears that TagNSearch reduced the amount of time to complete the task through the tag cloud view.

Table 2 shows the results of the heuristic evaluation. The values in the middle two columns (maximum of 5, minimum of 1) were obtained by calculating the mean of the responses of the participants. Values closer to 5 suggest strong conformance to a heuristic while values closer to 1 indicate weak conformance. From the table, participants rated most heuristics relatively highly with a score of around 4 for both systems. However, there are relatively large differences for 2 heuristics.

Table 1. Searching results using Flickr and TagNSearch of 16 participants

Photograph	TagNSearch		Flickr	
	Participants succeeded	Queries	Participants succeeded	Queries
Easy to recognize	95.83 %	2.7	70.83 %	5.1
Difficult to recognize	93.75 %	8.1	18.75 %	20.6

Table 2. Evaluation results using Nielsen's 10 usability heuristics

Heuristic	TagNSearch	Flickr	Difference
Visibility of system status	4.0	4.1	-0.1
Match between system and the real world	3.9	4.0	-0.1
User control and freedom	4.2	4.2	0
Consistency and standards	4.0	4.0	0
Error prevention	4.0	4.0	0
Recognition rather than recall	4.2	2.0	2.2
Flexibility and efficiency of use	4.1	2.1	2.0
Aesthetic and minimalist design	4.1	4.0	0.1
Help users recognize, diagnose, and recover from errors	4.0	4.0	0
Help and documentation	4.0	4.1	-0.1

For "Recognition rather than recall", participants using TagNSearch did not have to remember photograph thumbnails in each cluster, since they could view all of them in a single page (Section 4.1) unlike Flickr (Section 2). TagNSearch also supports search refinement through the tag cloud so that participants do not need to remember their previous search terms. In contrast, participants needed to click on a particular cluster to let the Flickr map highlight that cluster's photograph thumbnails in the current slide of the slide panel. Whenever a new slide was presented, they had to select the same cluster again to view highlighted thumbnails. Since thumbnails were found in different slides, they had to remember all highlighted thumbnails in all slides to get the overview of one particular cluster.

For "Flexibility and efficiency of use", Flickr users had to look through all photographs, navigate between results pages and determine new search terms to obtain relevant photographs. On the other hand, with TagNSearch, users can use the clusters and the tag clouds to identify photographs of interest.

Participants also had other comments for the TagNSearch interface. Many liked the idea of our clustering approach and the information contained within the clusters as

this made it easy to obtain an overview of a search. Further, the cluster sorting feature helped them to quickly find the most popular clusters or easily navigate to a particular country. Finally, the use of the tag cloud for search refinement was also considered a useful feature to find the photographs locations and relevant tags.

6 Conclusion

In this paper, we present TagNSearch, an approach to searching and navigating geo-tagged photographs. Photographs in a search are retrieved, clustered and visualized on a map interface. Each cluster is a set of geographically nearby photographs and is associated with a tag cloud that presents an overview of the photographs' tags in that cluster. The combination of clustering and the tag cloud help users better sift through the search results lists. Further, the tag cloud also lets users refine their search by reissuing the original query with the selected tag. A qualitative evaluation showed that the TagNSearch system was better able to help users identify locations for photographs better than Flickr's own search system.

Tag searching and tag clouds are not new ideas. Flickr provides a search service for tags, locations and full text. World Explorer helps users to search for a location and displays a tag cloud over that location. Compared to these systems, our evaluation shows that TagNSearch can perform search and tagging tasks more effectively when integrating the concepts of clustering and tag clouds than using these methods alone. Flickr does not support the use of tag clouds in clusters, and its clustering method and navigation between photographs does not adequately assist users in navigating large search results listings effectively. TagNSearch has the advantage of displaying photographs and related information for each cluster, and also allows users to narrow their search using the tag cloud. On the other hand, World Explorer only supports location search and the tag cloud it displays is generated from the tags of photographs in the entire map restricted by the map boundary. To overcome this problem, TagNSearch returns photographs which contain search terms and only uses these photographs to generate tag clouds for each cluster.

In future work, it would be helpful if TagNSearch allows users to manually geo-tag photographs directly using its map interface, as currently, this is done outside of the system. Another area of work involves automatically examining all non geo-tagged photographs and assigning suitable locations for them. An extension of our earlier work on place-name assignment for Web pages [20] could be used here.

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