Supporting Mobile Collaborative Searches with Query Suggestions

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ABSTRACT

People sometimes search collaboratively with others by using their smartphone in order to decide where to go, how to do, and what to do. We call such search situations "mobile collaborative searches". In a mobile collaborative search, users have a strong desire to make decisions to reach satisfactory conclusions; however they often cannot do that smoothly because of the difficulty of sharing their interest and search activities. The objective of our work is to support users who belong to a group of a mobile collaborative search in making decisions easily and effectively. We propose a method which suggests queries to group members by taking account of their search behaviors such as input queries and browsed pages. In addition, we implement a prototype system of the proposed method and carry out an experimental test to show the usefulness of our method.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Communications Applications

General Terms

Design

Keywords

collaborative search, mobile collaborative search, query suggestion, search behavior

1. INTRODUCTION

The explosive popularity of smartphones has enabled people to search the Web at any time and anywhere. According to VisionMobile, the ratio of smartphone users to all mobile phone users all over the world is 27% in H1 2011[9]. Additionally, the ratio is 46% in the U.S. The ratio for users from 25 years old to 34 years old is 71%[2].

Morris revealed that people often search the Web collaboratively with others by using desktop computers[5]. For example, group members search for information to plan their group trip in consideration of their budget and preference. In this paper, we call such search behavior involving several persons a collaborative search. People now have opportunities to search the Web collaboratively, not only using desktop computers but also using mobile computers because of the spread of smartphones. Here, we call the collaborative search with mobile computers "mobile collaborative search". In this work, we focused on the mobile collaborative search. For example, group members may search for sightseeing spots during a group trip, people might search for a restaurant for an impromptu party, others may search for information to find ways to get home together after some disaster, and so on. There is a great difference between a collaborative search using desktop computers and a collaborative search using mobile computers. In the latter case, people are more likely to begin to search on the spur of the moment and do not have as much time as in the former case. The displaying and sharing of information is restricted because of the small size of mobile displays in the case of the latter.

In a mobile collaborative search, users hope to make decisions and to reach satisfactory conclusions as a group. However, it is not easy to make decisions smoothly in a mobile collaborative search because of following two problems. The first is that group members tend to make redundant and similar searches. If each member begins and continues to search by similar queries about a target, the search range of the group is narrowed. Therefore, the group cannot cover many topics about the target, and consequently the group sometimes cannot find web pages that are relevant to group members' needs. As a result, they sometimes are not satisfied with their conclusion. The second point is that each member tends to search freely according to his or her own inclination. If each member searches only according to his or her own inclination, the search range remains inconsistent and group members cannot focus on the common purpose of the group. As a result, they sometimes cannot accomplish their purpose within a limited time, and they just waste time. As a result that, some sightseeing spots and stores may be closed and they may miss the last bus. There is trade-off relationship between these two points. The one point is narrow search range and another is wide one.

The purpose of our work is to solve the above problems and to enable users to carry out smooth decision-making in the mobile collaborative search. In this paper, we propose a novel query suggestion method which connects group members and estimates the degree of topic divergence and convergence of group members' search target and automatically controls it to allow a group to make decision smoothly, considering many alternatives. Here, "topic" means what a group is searching for at a certain time.

2. RELATED WORK

SearchTogether[6] is a system that enables a group of remote users to synchronously or asynchronously collaborate when searching the Web. This system provides functions with which each user shares input queries with other collaborative users, suggesting favorite pages, and adding evaluations and comments to a page. CoSearch[1] is a system that enables users to search collaboratively using one computer and more than one mouse and mobile device. Each user has a cursor distinguished by a different color. All cursors are shown on a display. Users operate their own cursor using a mouse and search collaboratively sending queries and pages to queue. As well as using mouse functions users can also input queries, browse pages, and add notes for a page using a mobile device. These studies assume that more than one computer can be used. This paper is different from these studies because we assume that only mobiles can be used.

Komaki et al.[3] proposed an interface to support the comparison and examination of Web content by sharing Web content which reflects users' opinions, and presenting it. Kotani et al.[4] proposed methods to support users in sharing information using various functions; a function of informing others about Web pages by inserting them into others' search results, and a function of displaying information related to others' search topics, and others. These studies assume collaborative searching using mobiles, and focus on comparing and sharing information and do not take care of query suggestion. In this paper, we do not support comparing and sharing information; instead we support making decisions smoothly by considering the divergence and convergence of topics.

3. PROPOSED METHOD

A mobile collaborative search is search behavior on a per-group basis and all group members hope to be satisfied, thus it is important to find pages that are satisfactory for all group members. However, it is not easy to make decisions smoothly in mobile collaborative searches as previously noted. According to section 1, we think that this is because redundant searches are conducted and there is no focus on the common purpose of the group. For example, one member input query "Kyoto Kinkaku-ji" and another member input query "Kyoto Kinkaku-temple" when planning to travel Kyoto. In this case, they spend much time to search for various sightseeing spots in Kyoto because of inputting similar queries. On the other hand, one member search for Japanese restaurants and another member search for French restaurants when searching for restaurants to have dinner. In this case, they cannot focus on one restaurant because of inputting inconsistent queries.

We introduce the concept of the divergence and convergence of a topic, Our method works to expand the search range of a group by suggesting queries for increasing the degree of divergence of the search if group members do redundant search. On the other hand, this method works to narrow the search range of a group by suggesting queries for increasing the degree of convergence of the topic if each group member's search topic is inconsistent. In this way, a group's decision-making can be facilitated. Here, we call a query for promoting divergence a "divergence query" and a query for promoting convergence a "convergence query".

In addition, we estimate how divergent and how convergent a topic is at a certain phase of a mobile collaborative search. We focus on how convergent a topic is and we call this rate the 'convergence degree' of a topic. A high convergence degree of a topic means that the topic is diverging, and a low convergence degree of a topic means that the topic is converging. The number of suggested divergence queries and convergence queries is changed using the convergence degree of the topic. In other words, the ratio of divergence and convergence of the topic is estimated dynamically, and then the suggested queries are changed dynamically.

3.1 Generation of Suggestion Queries

Our method estimates the approximate search intent of a group using each member's input queries and generate divergence queries and convergence queries based on the estimated intent. Here, the search intent is the context of a group, so we call the term that describes context the "context term".

3.1.1 Generating a Seed Query

Our method firstly detects a context term. A context term is regarded as a term which appears frequently in all queries in a mobile collaborative search, because the more frequently term in queries imply context. Then, our method generates a seed query to generate divergence and convergence queries. A query in a query history which contains a context term is regarded as a seed query that generates a divergence query and a convergence query.

3.1.2 Divergence Query

A divergence query is related to a seed query but has different viewpoint to the seed query. For example, we consider a case in which "Kyoto sightseeing" is a seed query. This query has two contexts; one of them is "searching for sightseeing spots when traveling in Kyoto" and the other is "searching for information about Kyoto while traveling in the Kansai region[1]". In the case of the former, because people can go shopping as well as sightseeing in Kyoto, "Kyoto shopping" can be a divergence query. In the case of the latter, because Osaka is another sightseeing spot in the Kansai region, "Osaka sightseeing" can be a divergence query.

Here, we focus on terms which contain each query, then *Kyoto* in the case of the former and *sightseeing* in the case of the latter occur in common, and each term corresponds to its context. Moreover, there is a coordinate concept relation between *sightseeing* and *shopping* in the case of the former, and there is also a coordinate concept relation between *Ky-*

[1]Kyoto is in the Kansai region

oto and *Osaka* in the case of the latter. Henceforth, we call a term which is a coordinate concept relation a "sibling term".

First, term t_1, which describes context, is selected from a seed query "t_1 t_2", and the sibling term t_2' of the residual term t_2 is found. Finally "t_1 t_2'" is generated as a new divergence query. Thus, a divergence query is generated. For example, if "Kyoto Kinkaku-ji" is a seed query, "Kyoto Ginkaku-ji" and "Kyoto Kiyomizu-Temple" are generated.

After selecting context term t_1 from query "t_1 t_2", we have to find a sibling term of residual term t_2. There have been many studies on the detection of sibling terms. In this paper, we refer to the research of Ohshima et al. [8]. We use API[2] to get the coordinate term.

3.1.3 *Convergence Query*

A convergence query is related to a seed query and contains more detail of it. For example, we consider a case in which "Kyoto sightseeing" is a seed query. If focusing on *sightseeing* and specializing it, "Kyoto sightseeing red-leaves" can be a convergence query because it means that people want to sightsee in Kyoto and observe red leaves. Moreover, when focusing on *Kyoto*, "Kyoto Arashiyama sightseeing" can be a convergence query because it means that people especially want to visit in Arashiyama[3] in Kyoto.

Here, we focus on a term in a query, *red-leaves* is a term which specializes *sightseeing* in *Kyoto* as a context term and *Arashiyama* is a term which specializes *Kyoto* in *sightseeing* as a context term. Henceforth we call a term which specializes another term like this a 'detail term". Additionally, a seed query can be a convergence query for users except those who input the seed query because it means focusing on the group members' intent.

First, term t_1 which describes context is selected from a seed query "t_1 t_2", and detail term t_3 of the residual term t_2 is found. Finally "t_1 t_2 t_3" is generated as a new convergence query. Also, seed query "t_1 t_2" is regarded as a convergence query. Thus, a convergence query is generated. For example, if "Kyoto Kinkaku-ji" is a seed query, "Kyoto Kinkaku-ji history" and "Kyoto Kinkaku-ji red-leaves" are generated.

After selecting context term t_1 from query "t_1 t_2", we have to find a detail term of residual term t_2. There have been many studies on the detection of detail terms. In this paper, we refer to the research of Noda et al. [7]. We use foregoing API to get the topic term.

3.2 Convergence Degree of a Topic

We focus on the similarity of browsed pages and selected suggestion queries in order to calculate the convergence degree of a topic in a group search on one occasion.

First, we use a weighted mean of similarity between a browsing page and each page which has been browsed at a point. When this value is low, it follows that group members are browsing non-similar pages and the topic is divergent. When this value is high, it follows that group members are browsing similar pages and the topic is convergent. Second, we use the ratio of convergence queries to the latest suggestion queries selected by each user. If many divergence queries are selected in suggestion queries, it is considered that a topic is divergent. On the other hand, if many convergence queries are selected in suggestion queries, it is considered that a topic is convergent. We use these elements to calculate convergence degree of a topic.

[2]http://www.dl.kuis.kyoto-u.ac.jp/~ohshima/wiki/index.php?YayalaAPI

[3]Arashiyama is a famous sightseeing spot in Kyoto.

Figure 1: A main screen

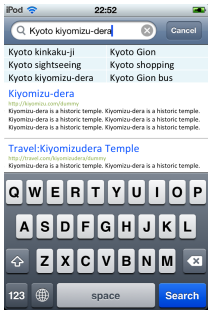

Figure 2: A keyboard of main screen

3.3 Implemantation

We implemented a prototype system employing a server/client model. The server side implemented by Python operates as CGI and the client side implemented by Objective-C operates on terminals with iOS5.0. Fig. 1 is the main search screen. There is a search bar to input a query at the top and a keyboard appears as in Fig. 2 if the user taps the search bar. There is an area which shows suggestion queries between the search bar and the search results.

4. EVALUATION EXPERIMENT

We conducted an experiment in which we asked subjects to carry out tasks in a collaborative search to clarify the usefulness of our proposed method. Through the experiment we clarified whether divergence queries enabled users to search comprehensively and to consider many alternatives, whether convergence queries enabled users to search with better focus, and whether the suggestion queries enabled users to make decisions smoothly.

In order to confirm the usefulness of our system, we prepared a baseline system whose function was almost the same as the prototype system, although slightly different. This baseline system imitates query suggestion by general relative keywords and is not supposed collaborative search. In the baseline system, suggestion queries are generated by API to get relative searching terms from Yahoo! Japan.

4.1 Experiment Method

First, we provided an explanation of a task to each group that consisted of four subjects and required them to search collaboratively. After that, we asked them to discuss their collaborative search activities, and then to fill out a questionnaire. Each group followed this procedure once for each method. Four people all knew each other in each group. The number of groups was eight, and the subjects were 32 males

Table 1: About queries

	# of queries	# of unique queries
proposed	18.6 ($\sigma = 6.0$)	14.0 ($\sigma = 3.2$)
baseline	19.6 ($\sigma = 4.2$)	16.0 ($\sigma = 3.5$)
	suggestion queries / input queries	
proposed	31.5%	
baseline	13.4%	

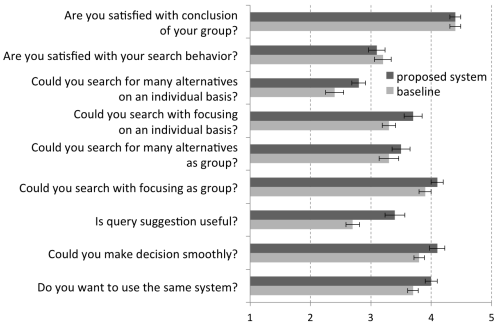

Figure 3: Results of questionnaire

and females. They were between 18 and 33 years old, and the average age was 22.3 years old. Subjects tried two tasks using the proposed system and the baseline system. Each task had a time limit up to 10 minutes. The experiment was carried out in a situation in which the subjects were standing up in a room of $20m^2$ and could see a timer which showed elapsed time.

4.2 Results of Experiment

Table 1 show the number of input queries based on operation logs. The number of queries and the number of unique queries were a little more in the baseline than in the proposed system because the same queries were suggested to each user in the proposed system. However, the ratio of selected suggestion queries to input queries was 31.5% in the proposed system and 13.4% in the baseline. The ratio of the proposed system was much higher than that of the baseline. As a result, we can say that the proposed system might be proved to suggest more interesting queries.

Fig. 3 shows the results of the questionnaire. There was no significant difference in the questions "Are you satisfied with the conclusion of your group?" and "Could you make decisions smoothly?" between our system and the baseline. However, there was a significant difference ($p < 0.05$) in the questions "Could you search for many alternatives on an individual basis?" and "Were the query suggestions useful?"; here, our system got better results.

5. DISCUSSION & CONCLUSION

There was little difference in satisfaction with the conclusion reached and subjects' own searching behavior between the proposed system and the baseline. However, the score for whether a user can search for many alternatives and whether a user can search with focus was higher in the proposed system than in the baseline. Because there was no difference in satisfaction between the proposed system and the baseline, we think that we should devise an experiment with more difficult tasks and which is conducted in a shorter time

Table 1 shows that the number of queries and unique queries by using the proposed system were fewer than by using the baseline. However, the ratio of selected suggestion queries to input queries of the proposed system was much higher. We think this is why there were many useful suggestion queries. Additionally, we think that that query suggestion was useful in the proposed system, because the score of the question "Was query suggestion useful?" was high.

In the future work we will improve the method of generating suggestion queries because the accuracy of suggestion queries is not so good at present. Additionally, the same queries were suggested to all users; however users are not always equal because they sometimes conduct the same searches, and their prior knowledge is sometimes different. For this reason, we think we will change the suggestion queries given to each user.

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