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A Location-based Content Search System Considering Situations of Mobile Users

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Abstract

Mobile devices have become popular to access the information on-the-move. Users carry around mobile devices all the time, and thus they often search location-based contents (e.g., locations of specific spots around them, reviews about the spots, and routes to the spots) in their daily life. However, physical restrictions of mobile devices such as display size and input capabilities affect users' operations, e.g., it is difficult to input a search query and move to another page. When searching contents by using mobile devices, users' situations often change and this change may affect the users' information needs. Therefore, it is effective that search systems provide users with information suitable for the users' situations. In this paper, we present the design and implementation of a location-based content search system considering mobile users' situations, which aims to reduce users' load of operations in content searching when users stand or sit and can concentrate on the display to some extent. Our system decides the importance of each location-based category (whether useful for users or not) based on the users' situations and presents the information related to high-importance categories on the menus and map. Users can get contents by only selecting menus and markers on a map. We conducted a user experiment with 11 people. The experimental result shows that users could get contents more easily using our system than using a commercial Web search system and map search system.

Keywords: Mobile device; Context-aware; Content search; Map; Menu

1. Introduction

Due to the proliferation of smartphones equipped with high functional OS such as iOS and Android, it has become easy for people to search and browse information in the same way as on PCs. A recent survey conducted in Japan in December 2009 shows that more than 40% of people in Japan use some search sites on mobile phones. This shows that mobile phones have become not only communication tools but also tools for fulfilling information needs while on-the-move. Since mobile users carry around mobile devices all the time, they often search location-based contents (e.g., locations of specific spots around them, reviews about the spots, and routes to the spots) in their...
daily life. Church et al. [2] reported that geographical searches tend to happen in a mobile situation, i.e., in their user study, 75% of geographical searches happened in a mobile situation. Therefore, applications and services for mobile users should be designed to take into account users’ contexts such as locations. Recently, some companies have provided services which take mobile situations into consideration. For example, mobile search services provided by TellMe2 utilize a GPS to sense users’ current locations, so that, for example, a query “coffee” returns a map showing nearby coffee shops. As a service in Japan, iConsier3 pushes information which might be useful for users considering their current locations.

When getting location-based contents, mobile users generally use applications such as Web search engines and online maps. Sohn et al. [11] reported the result of a user study that the most popular ways were Web access (30%) and online maps (10%) to search contents by using mobile devices. Regarding Web search engines, although users can get a variety of information on the Web, they have difficulty in selecting contents of interest from an enormous pool of information and grasping geographical information. Regarding online maps, although users can grasp geographical information, they cannot get enriched text-based information. Since mobile phones have only small screen and restricted input interfaces, it is a laborious task to input search queries and move to another page. In our previous work [6], we found that 40% of reasons that mobile users failed to search was users could not find appropriate queries. This survey shows that it is laborious for users to find appropriate queries and input them.

Additionally, a typical characteristic of mobile users’ location-based content search is the change of users’ situations such as users’ activities and surrounding environment, which may affect the users’ information needs. For example, when a user goes out with his/her friend in downtown, contents related to cafe are important around 15:00, while that related to dinner are important around 19:00. Church et al. [2] reported also that half of mobile searches are related to users’ activities, and thus, it is effective that search systems provide users with information which is useful for the users considering users’ situations.

In this paper, we present the design and implementation of a location-based content search system considering mobile users’ situations, which aims to reduce users’ load of operations in content searching. Here, a survey conducted in Japan in 2010 [7] shows that most mobile users in Japan access the Internet in standing or sitting situations such as at a restaurant (35%), in a train (37%), at their work place (45.5%), and at their home (72%). Thus, our target users in this work are who stand or sit and can concentrate on the display of their mobile devices to some extent. Our system determines the importance of each location-based category (how useful the information for users is) based on the users’ situations and then presents the information related to high-importance categories by using menus and a map. Users can get contents by selecting a menu or a marker on the map which they are interested in. We conducted a user experiment with 11 people. The experimental result shows that users could get contents more easily using our system than using a commercial Web search system and map search system.

The remainder of this paper is organized as follows. Section 2 describes related works. Section 3 presents the design and implementation of our system. Section 4 presents the user experiment and discuss the result. Finally, Section 6 concludes this paper.

2. Related work

Naganuma et al. [8] proposed a task-oriented menu system which enables users searching for mobile internet services by specifying “what they want to do”, not by specifying “the name of the category of the desired service”. They evaluated a prototype system and showed that users can reach his/her desired mobile services faster than existing domain-oriented menu systems and keyword search. However, this system is designed based on an ad hoc model targeting users’ activities at an amusement park. Sasajima et al. [10] proposed a ontology-based task modeling method which supports the description of users' activities and related knowledge such as how to solve problems that the users have. These systems present menus which are prepared based on general (typical) situations of mobile users without considering the users’ current situations. On the other hand, our system provides information by using menus and a map based on the users’ current situations.

Some studies that aim to provide information considering the users’ current situations have been conducted. The Cyber Guide [1] is a navigation system in a town based on the user’s current location. It provides a map of roads and

2 http://www.tellme.com/
3 http://www.nttdocomo.co.jp/service/customize/iconcier
buildings based on the user's location which is detected by using infrared rays indoors or by using GPS outdoors. iShop [9] is a navigation system which aims to support users' shopping at a large grocery store. Taking into account items' situations such as the amount of stock and the layout in the store, this system navigates users in the store by re-ordering the shopping item list, which is pre-registered by the users, so that the users can do shopping effectively. CoCo [5] is a context-aware content delivery system which recommends some stores based on the user's current situation detected by using mobile off-the-shelf sensors. It assumes navigation in only a town in Japan and uses the pre-registered store list. As described above, these existing systems only assume limited situations.

To search location-based contents, geographical information on a map is important. There are a large number of map-based applications for mobile devices such as Google Map4. Some conventional studies assume a map-based interface to support users searching location-based contents. Question-Not-Answers [4] provides users with previous queries relating to the user's location. It displays queries issued by other people at the same location using a map-based interface, providing users with an enriched sense of places. Social Search Browser [3] is a similar system to Question-Not-Answers. It leverages users' social networks and can filter queries not only by their locations but also by the reliability of people. These systems require inputting a query when searching contents and consider only users' locations and social relations. On the other hand, our system requires users to only select menus and adaptively changes information presented on the menus and map not only by the user's current location but also by the user's detailed situation.

3. Proposed system

In this section, we describe the design policies of our system, and then present the system behavior.

3.1. Design policies

We set the following design policies based on the characteristics of content search by mobile devices.

(1) Easy and few operations: Since mobile devices have restricted input interfaces, it is important to reduce laborious operations such as inputting search queries and moving to another page.

(2) Easy to grasp information: Since mobile devices have only a small screen, we should present a suitable amount and style of information for users.

(3) Adapting to users' situations: The change of mobile users' situations affects their information needs, and thus, we should adapt the information presented on the screen to users' situations. Specifically, it is important to provide users with information which is useful in their situations.

To achieve these design policies, our system presents location-based information using menus and a map and provides the following functions. To satisfy policy (1), our system provides categorized menus so that users can get contents by only selecting a menu of interest a few times. Furthermore, it directly presents contents on the top of menus without navigating to another page. To satisfy policy (2), our system narrows down the number of menus and markers on a map to support users' interactions. Additionally, it presents the information in menus and markers on a map in different colors according to their categories so that users can easily grasp the outline and geographical information of the contents. To satisfy policy (3), our system predicts users' situations by using some sensing devices and presents the information suitable for the users' information needs in the predicted situations.

3.2. System behavior

As Fig. 1 shows, our system presents the information that might be useful for users considering their situation by using menus and a map. Specifically, markers corresponding to the locations of spots around users are presented on the map and location-based category names and spot names are presented as selectable menus. Users can get location-based contents (e.g., outline about a spot, Web search results of a spot, reviews about a spot, and a route to a spot) by selecting menus of interest, moving maps, and selecting markers. To enable users getting useful information according to their situations, our system first predicts users' current situations by using some sensing

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4 http://www.google.com/mobile/maps/
devices and decides the importance of location-based categories according to the predicted situations. Then, it presents the information related to the high-importance categories by using menus and a map.

In the following, we describe the details of our system behavior.

3.2.1. Predict users’ situation

First, our system predicts a user’s current situation based on the user’s activity (walking, running, and standing) by using an acceleration sensor, GPS, time, and profile (the user’s home address and his/her business address) which is pre-inputted by the user. Our system targets situations that users stand, so it runs only when users’ activity is standing. In the current implementation, by using users’ locations, time, and profile, we can predict some detailed users’ situations such as being at the office at lunch time on weekdays and going out downtown at noon on a holiday.

3.2.2. Calculate importances of categories

After predicting the user’s situation, our system calculates the importance of each location-based category. In the situation that the user is at the office at lunch time on weekdays, users are supposed to go for lunch or draw money from the bank, and thus, contents related to categories of restaurant such as cafe and that of public spots such as bank are important for users. On the other hand, in the situation that users go out to downtown at noon on a holiday, users are supposed to have lunch or see a movie with high probability, and thus, contents related to categories of restaurant such as buffet and that of entertainment such as theater are important for users. Our system presents preferentially the information related to high-importance categories on menus and markers on a map.

Here, we represent location-based categories as a tree (category tree) having three layers, which is constructed based on categories described in Google Places\(^5\). Nodes at depth 1 represent nine types of abstract categories such as restaurant. Nodes at depth 2 represent concrete categories belonging to each abstract category such as cafe. Nodes at depth 3 represent spot names belonging to each concrete category such as Hard Rock Cafe Niagara Falls. Our system gets the information on a spot around the user’s current location by using Google AJAX Search API\(^6\) and adds it as a node at depth 3 to the category tree. Briefly, our system constructs the category tree by using pre-defined abstract and concrete categories and by adding dynamically spot names.

After constructing the category tree, as Fig. 2 shows, our system calculates the importance of each tree node according to the probability table. The probability table is a table that defines how important each category is in each of users’ situations. The importance of a node is calculated by multiplying a probability score, which is described in the probability table and represents the likelihood it happens when an event corresponding to its parent node happened. Note that probability scores change according to users’ situations. In the current implementation, we manually made the probability table.

\(^5\) http://www.google.com/places/
3.2.3. Present information on a map and menus

Our system shows the information corresponding to high-importance nodes in the category tree by using menus and a map. Users can select one of the three presentation styles: (i) **Menu+Map** (Fig. 1(a) and (b)), (ii) **Menu** (Fig. 1(c)), (iii) **Map**, by pushing the Map/Menu button. To support users’ interactions, our system presents only the information belonging to the category which the users selected on menus or a marker on a map.

Our system first presents the information in the **Menu+Map** style, where three abstract categories with the highest importances are presented as menus and the locations of spots belonging to these categories are presented as markers on the map as Fig. 1 shows.

In the following, we describe the detail of each function in our system.

- **Presenting categories**
  Our system uses different colors for different categories so that users can easily recognize menus and markers containing similar information. Specifically, the color of a marker/menu is determined according to the abstract category to which the information of the marker/menu belongs.

- **Presenting menus**
  Our system displays abstract categories with high-importance, concrete categories, and spot names as menus referring to nodes of the category tree. **Menu** presents six abstract categories with the highest importance and three concrete categories with the highest importance belonging to each of the six abstract categories. **Menu+Map** presents only three abstract categories with the highest importance to reduce the amount of text-based information. When searching information related to abstract categories with low importance, users can find menus belonging to those categories by pushing Next/Pre buttons. When users select an abstract/concrete category, as Fig. 3(a)/Fig. 3(b) shows, some concrete categories/spot names belonging to the selected abstract/concrete category are added to menus.

- **Presenting a map**
  To enable users easily grasping geographical information of location-based contents, our system shows the locations of spots around a user, which are corresponding to leaf nodes of the category tree, as markers on the map. When users select a marker, as Fig. 3(c) shows, a balloon showing the spot name corresponding to the selected marker and its abstract category is presented on the marker. Since showing too many markers on a map is troublesome for users, our system narrows down markers presented on a map, i.e., only markers belonging to the category selected by the user are presented.

- **Presenting contents**
  When users select a spot name on menus or a balloon on the marker, goal contents are directly displayed under the spot name without navigating to another page. Since users need text-based information on location-based contents such as spot name, address, telephone number, reviews from other users, and Web search results, our system extracts such information from Google Places’ pages and shows it on tab menus (Fig. 3(c)). Thus, users can
easily browse such rich information by only selecting tab menus. Furthermore, since users often need the information on a route from the users' current locations to a certain spot, our system offers a facility of route search. Users can easily search a route search by selecting “route search” option on the balloon on the marker.

4. Experiment

4.1. Experimental setting

Participants were eight men and three women from our laboratory. The participants performed twelve search tasks using three systems on iPhone: our system, Web search system (Google search), and map search system (Google map). Searching contents by using the Web search system and map search system requires participants to input queries. In this experiment, participants freely searched contents in four situations (Morning on a weekday, Lunch time on a weekday, Downtown at noon on a holiday, Downtown at night on a holiday) using each system.

In order to keep the fairness among the systems, we divided participants into six groups and assigned each group a different order of using the three systems. During the experiment, the number of operations for each task was recorded. We conducted a questionnaire survey to evaluate participants' subjective impression to our system. Specifically, when finishing the experiment, we asked participants to score each system regarding the following aspects using 5 scale points (−2 to 2), where −2 means strongly disagree while 2 strongly agree: The number of operations was few, Operations of the system were intuitive, The system was convenient to find information of interest, and The presented information was suitable for your situation (only for our system). We also accepted free opinions from the participants.

4.2. Experimental result

4.2.1. Number of operations

Fig. 4 shows the distribution of the numbers of operations for all tasks, which were obtained from the recorded operation logs. The numbers of operations were widely distributed, thus, we conducted the Kruskal Wallis test, which is a non-parametric test used for examining differences among groups, with 5% significance level. As the result, we found no significant difference among the three systems.

As Fig. 4 shows, while the ratio of less than six operations using our system was 60%, that using the map search
system was 7%, and that using the Web search system was 0%. This result shows that the number of operations on searching contents using our system was less than those using the comparison systems for many participants.

However, in some cases, the number of operations using our system was more than those using the comparison systems. This is due to the participants who had difficulty in operating a map. The participants also tended to need a large number of operations when using the map search system. Additionally, two participants said that operations to move and scale a map were laborious on the map search system. Therefore, it is effective to automatically move and scale a map considering users' situations and contents presented.

4.2.2. Questionnaire survey

Tables 1 and 2 respectively show the result of the questionnaire survey about The number of operations was few and Operations of the system were intuitive. From Table 1, while the percentage of participants who felt that operations were few (selected 1 or 2) with our system was 91%, that with the Web search system and the map search system were respectively 9% and 18%. From Table 2, while the percentage of participants who felt that operations were easy (selected 1 or 2) with our system was 100%, that with the Web search system and the map search system were respectively 18% and 36%. This is because the comparison systems require to input queries and select the search results, while our system requires only to select categorized menus. From this result, we confirmed that operations on our system were few and easy.

For our system, five participants said that menus and markers colored according to their categories were helpful grasp the information. Two participants said that tab menus on outline, reviews, and Web search results were useful and presenting a map and menus on a same page was easy to operate. On the other hand, for the comparison systems, these two participants said that moving to another page is laborious. This result shows that it is effective to present additional information on a same page without navigating to another page.

Table 3 shows the result of the questionnaire survey about The system was convenient to find information of interest. From this result, while the percentage of participants who felt that the system was convenient to find information of interest (selected 1 or 2) with our system and the Web search system were respectively 81% and 82%, that with the map search system was 54%. In the Web search system, users could search all kinds of contents on the Web. In our system, users could search a variety of contents such as route, address, and reviews related to predefined categories. On the other hand, in the map search system, kinds of contents presented on a map were not
Table 3. The system was convenient to find information of interest.

<table>
<thead>
<tr>
<th>Score</th>
<th>–2: strongly disagree</th>
<th>–1</th>
<th>0</th>
<th>1</th>
<th>2: strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our system</td>
<td>0%</td>
<td>9%</td>
<td>9%</td>
<td>36%</td>
<td>45%</td>
</tr>
<tr>
<td>Web search system</td>
<td>0%</td>
<td>9%</td>
<td>9%</td>
<td>27%</td>
<td>55%</td>
</tr>
<tr>
<td>Map search system</td>
<td>9%</td>
<td>18%</td>
<td>18%</td>
<td>45%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Table 4. The presented information was suitable for your situation.

<table>
<thead>
<tr>
<th>Score</th>
<th>–2: strongly disagree</th>
<th>–1</th>
<th>0</th>
<th>1</th>
<th>2: strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our system</td>
<td>0%</td>
<td>9%</td>
<td>27%</td>
<td>9%</td>
<td>55%</td>
</tr>
</tbody>
</table>

enough for users because users cannot get the detailed information about a spot if they do not select a spot name on the balloon on a marker and move to another page.

Table 4 shows the result of the questionnaire survey about The presented information was suitable for your situation (only for our system). From this result, the percentage of participants who felt that the presented information was suitable for their situation (selected 1 or 2) was 64%, that felt not suitable (selected –1 or –2) was 9%, and that felt neutral (selected 0) was 27%. Two participants said that they could get contents of interest without using Next button. From this result, while we could confirm to some extent that our system can present useful information considering users' situations, its effectiveness differs between individuals. Therefore, we should expand our system to present information considering users' profiles in more detail, e.g., age, reference, and schedule.

5. Conclusion

In this paper, we presented the design and implementation of a location-based content search system considering mobile users' situations. This system aims to reduce users' load on operations in content searching when users stand or sit and can concentrate on the display of their mobile devices. Our system determines the importance of each location-based category based on users' situations and presents the information related to high-importance categories on menus and a map. Users can get contents by only selecting menus and markers on a map. We conducted a user experiment with 11 people. The result shows that users could get contents using our system more intuitively and less laboriously than using the commercial Web search system and map search system.

As part of our future work, we plan to extend our system to improve to predict users' situations and calculate importances of categories by learning users' profile, usage histories, and feedback.

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References