Attribute-Driven Approach for Fuzzy Query and Location-Based Personalized Web Page Ranking Algorithm in Smart Phones

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Abstract—Attribute-driven approach for fuzzy query and location-based personalized web page ranking algorithm in smart phones are proposed. It is based on voice web search, user’s physical location, search distance, search directory and user’s search intentions. Kinking these issues is technologically demanding and potentially useful in smart phones.

Fuzzy query; attribute-driven approach; location-based personalized web page ranking algorithm; smart phones

I. INTRODUCTION

With Embedded ViaVoice® technology[10] behind today’s small mobile devices and automotive telematics systems, it provides automatic speech-recognition and text-to-speech capabilities for small mobile devices, including automotive telematics systems [3] and hands-free phones. Now, Google provides smart phone users with voice search [8]. That is, avoid typing your search query while searching for nearby businesses (e.g. ‘pizza’ or ‘sushi’). A smart phone user can download voice search application from Google Mobile App [8]. Using the voice search application in Google phone, a user speaks search queries in English, Korean, Japanese, etc. Similarly, iPhone 4 makes a phone call, plays music, and more using only your voice [9]. However, existing smart phones have some problems in handling fuzzy query in voice web search. To tackle this problem, attribute-driven approach for fuzzy query in smart phones is proposed. In addition, location-based personalized page ranking algorithm is proposed. It is based on voice web search, user’s physical location, search distance, search directory and user’s search intentions.

II. LOCATION-BASED WEB SEARCH IN CURRENT SMART PHONES

We assume that each smart phone has the voice web searching component and a GPS [11] receiver. In this case, a user can search the web with location tag (i.e., latitude, longitude, etc.). Thus, the user’s physical location in conjunction with the relevant keywords provides users with a local angle to make searching for local businesses on the web as shown in Figure 1.

III. ATTRIBUTE-DRIVEN APPROACH FOR FUZZY QUERY IN SMART PHONES

A search engine, on receiving a query, would compare the query with its document index (DI) [4]. All of the pages that match the user query will be selected into an answer set and ranked according to how relevant the pages are for a given query. The DI generally consists of keywords that appear in the title of a page or in the text body. Based on the DI, commercial web search engines help users to retrieve information. However, we cannot automatically extract such content from general documents yet [5]. In addition, they cannot properly process fuzzy queries. For example, they cannot properly handle a fuzzy query that finds ‘famous sushi’ restaurants from user’s physical location within a specified area. A specified area is a search distance for web searching. In this fuzzy query, we note that the user wants to find ‘famous sushi’ restaurants, not just ‘sushi’ restaurants. In short, commercial web search engines do not properly reflect user’s search intentions[4]. To handle location-based fuzzy queries in smart phones, we propose attribute-driven approach for fuzzy queries. For example, if a traveler is visiting San Francisco and tries to find ‘famous sushi’ restaurants within 2 miles from a smart phone user on the web, he/she tells a fuzzy query ‘famous sushi’. In this case, the fuzzy term ‘famous’ is a constraint on the focal keyword ‘sushi’ and fuzzy term is processed as follows:

Step 1 : Display search directories such as restaurants, entertainments, etc.
Step 2 : Select the directory that a user tells. It is consisted of attributes related to the directory. In case of the directory ‘restaurants’, a kind of ‘restaurants’ (Japanese, Chinese, Mexican, Korean, etc.), prices of foods and search distance may be suggested as attributes. Now, a user selects his/her preferences.
Step 3 : To handle the fuzzy term ‘famous’ related to the focal keyword ‘sushi’, the attributes may be ‘visitors/day’, ‘tastiness’, etc. Tastiness can be ranked by gourmards, ranked by the opinion of customers, etc. To reflect user’s preferences, a user selects the values of attributes.
Step 4 : Combine the results of Steps 1 ~ 3 with LWI and GIS in Figure 1, and it makes location-based personalized web search in smart phones.

Let the set of ‘sushi’ restaurants from user's physical location within a specified area be \( A = \{ A_1, A_2, \ldots, A_{99}, A_{100} \} \) and each \( A_i \) has its own URL.

Example1: Consider a crisp query that finds ‘sushi’ restaurants from user's physical location within 2 miles (Q).

Example2: Consider a fuzzy query that finds ‘famous sushi’ restaurants from user's physical location within 2 miles (Q).

Example3: Consider a fuzzy query that finds ‘famous sushi’ restaurants within 2 miles from user's physical location (Q).

Example4: Consider a fuzzy query that finds ‘famous sushi’ restaurants within 2 miles from user's physical location and the user selects the values of attributes (Q).

Example5: Consider a fuzzy query that finds ‘famous sushi’ restaurants within 2 miles from user's physical location and the user selects the values of attributes and it makes location-based personalized web search in smart phones.
In this case, the phase 2 (i.e., attributes for fuzzy terms) in Figure 2 is not used. Thus, the results are as in Table 1.

<table>
<thead>
<tr>
<th>DI</th>
<th>IPs</th>
<th>Attributes</th>
<th>FPs (Results)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_1</td>
<td>-</td>
<td>A_1</td>
<td></td>
</tr>
<tr>
<td>Sushi</td>
<td>A_2</td>
<td>-</td>
<td>A_2</td>
</tr>
<tr>
<td></td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>A_{100}</td>
<td>+ Irrelevant URLs</td>
<td>+ Irrelevant URLs</td>
<td></td>
</tr>
</tbody>
</table>

We note that IPs and FPs are equal. Thus, users receive locally targeted search results based on the focal keyword ‘sushi’ in the DI, user’s physical location, search distance and search directory ‘restaurants’.

**Example 2:** Consider a fuzzy query that finds ‘famous sushi’ restaurants from user's physical location within 2 miles (Q_2). In this case, both phases 1 and 2 in Figure 2 are used. The DI and attributes may be as follows: DI = {sushi}, attributes = {no. of visitors}. We note that a focal keyword ‘sushi’ is restricted by a fuzzy term ‘famous’. In this case, the fuzzy term ‘famous’ may be manipulated by the number of visitors per day, and represented by a membership function as in Figure 3. The value of focal attribute ‘no. of visitor’ (e.g., ‘no. of visitors’ per day ≥ 100) is given by a user. We assume that Q_2 is A_F, A_F ∈ {A_1, A_2, ..., A_{99}, A_{100}}, by using α-cut as in Figure 3. In this case, the results are as in Table II.

<table>
<thead>
<tr>
<th>DI</th>
<th>IPs</th>
<th>Attributes</th>
<th>FPs (Results)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sushi</td>
<td>A_{100}</td>
<td>No. of visitors</td>
<td>URLs w.r.t {A_F}</td>
</tr>
<tr>
<td></td>
<td>+ Irrelevant URLs</td>
<td>+ Irrelevant URLs</td>
<td></td>
</tr>
</tbody>
</table>

Thus, smart phone users receive more personalized and locally targeted search results (A_F) based on the focal keyword ‘sushi’, the value of focal attribute ‘no. of visitor’, user’s physical location, search distance and search directory ‘restaurants’.

**Algorithm 1:** Ranking for one focal attribute

(i) Monotonically nondecreasing case

The larger the value of focal attribute, the higher the rank retrieved documents for a given fuzzy query.

(ii) Monotonically nonincreasing case

The larger the value of focal attribute, the lower the rank retrieved documents for a given fuzzy query.

(iii) Unimodal case

If an interval of focal attribute determined by α-cut is [a, b]J, and let β denote the midpoint between a and bJ, then the degree of closeness (nearness) to β can be used as a ranking criterion. That is, the closer the β, the higher the rank retrieved documents for a given fuzzy query.
Let the personalized and locally targeted search results $A_F$ be $\{A^1_F, A^2_F, \ldots, A^i_F\}$ taking values of focal attribute (i.e., no. of visitors) such as $\text{Val}(A^1_F) \leq \text{Val}(A^2_F) \leq \ldots \leq \text{Val}(A^i_F)$, then the results $A_F$ are ranked as the following order: $A^1_F, A^2_F, A^3_F, \ldots, A^{i-1}_F, A^i_F$.

**Example 4:** Consider a fuzzy query that finds ‘low-price sushi’ restaurants from user's physical location within 2 miles. In this case, the fuzzy term ‘low-price’ may be represented by a monotonically nonincreasing membership function. We assume that ‘low-price sushi’ restaurants from user's physical location within 2 miles are $A_{LP}$ by using $\alpha$-cut. Let the personalized and locally targeted search results $A_{LP}$ be $\{A^1_{LP}, A^2_{LP}, \ldots, A^i_{LP}\}$ taking values of focal attribute (i.e., price) such as $\text{Val}(A^1_{LP}) \leq \text{Val}(A^2_{LP}) \leq \ldots \leq \text{Val}(A^i_{LP})$, then the results $A_{LP}$ are ranked as the following order: $A^1_{LP}, A^2_{LP}, \ldots, A^i_{LP}$.

**Example 5:** Consider a fuzzy query that finds ‘moderate-price hotels’ from user's physical location within 2 miles. In this case, the fuzzy term ‘moderate-price’ may be represented by a unimodal membership function. We assume that ‘moderate-price hotels’ from user's physical location within 2 miles are $A_{MP}$ by using $\alpha$-cut. Let an interval of focal attribute (i.e., price) determined by $\alpha$-cut be $[a_{\alpha}, b_{\alpha}]$, and let $\beta$ denote the midpoint between $a_{\alpha}$ and $b_{\alpha}$, and let the personalized and locally targeted search results $A_{MP}$ be $\{A^1_{MP}, A^2_{MP}, \ldots, A^i_{MP}\}$ taking values of the focal attribute such as $\text{Val}(A^1_{MP}), \text{Val}(A^2_{MP}), \ldots, \text{Val}(A^i_{MP})$. If the degree of closeness (nearness) to $\beta$ is the order $\text{Val}(A^1_{MP}), \text{Val}(A^2_{MP}), \ldots, \text{Val}(A^i_{MP})$, then the results $A_{MP}$ are ranked as the following order: $A^1_{MP}, A^2_{MP}, \ldots, A^i_{MP}$.

**Example 6:** In case of ranking for multiple focal attributes, we consider a fuzzy query that finds ‘famous and low-price sushi’ restaurants from user's physical location within 2 miles. In this case, the fuzzy terms ‘famous’ and ‘low-price’ may be represented by a monotonically nondecreasing membership function and a monotonically nonincreasing membership function, respectively. Using the results of Examples 3 and 4, if the weight of focal attribute ‘no. of visitors’ is more important than the weight of focal attribute ‘price’, then the personalized and locally targeted search results are ranked as the following order: $A^1_F, A^2_F, A^i_F, A^1_{LP}, A^2_{LP}, \ldots, A^i_{LP}$.

**V. COMPARISONS**

We briefly summarize the differences between the proposed smart phone and existing smart phones in Table III.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>The proposed smart phone</th>
<th>Existing smart phones</th>
</tr>
</thead>
<tbody>
<tr>
<td>UI</td>
<td>Voice +Text+Touch</td>
<td>Voice+Text+Touch + Fuzzy query</td>
</tr>
<tr>
<td>Fuzzy terms</td>
<td>Yes</td>
<td>Limited</td>
</tr>
<tr>
<td>Page ranking</td>
<td>Location+Search intentions</td>
<td>Location</td>
</tr>
</tbody>
</table>

**VI. CONCLUSIONS**

Attribute-driven approach for fuzzy query and location-based personalized web page ranking algorithm in smart phones are proposed. The proposed approach provides smart phone users with more personalized and locally targeted search results. It is a further step toward location-based personalized web search for smart phone users.

**REFERENCES**

GPS satellites

Smart phone tracking

Smart phone users

Query = keyword + location tag

Locally targeted results

Web search engine

LWI

GIS

Figure 1. Location-based web search in current smart phones

Phase 1: User’s physical location + search distance + search directory

Submit a fuzzy query

A set of all pointers

Phase 1: Projection by DI (i.e., Keyword)

A set of IPs

Phase 2: User’s preference by attributes

PLTR (FPs)

* LWI: Local Web Information
* GIS: Geographic Information System

Figure 3. A membership function of ‘famous’

(i) Monotonically nondecreasing (ii) Monotonically nonincreasing (iii) Unimodal

Figure 4. Three types of quantifiers

Figure 2. Location-based personalized web search in smart phones

* PLTR: Personalized & Locally Targeted Results (FPs)
* IPs: Intermediate Pointers
* FPs: Final Pointers

GPS-enabled smart phones

Voice web search: GPS-enabled smart phones

GPS satellites

Submit a fuzzy query

A set of all pointers

Phase 1: Projection by DI (i.e., Keyword)

A set of IPs

PLTR (FPs)

* PLTR: Personalized & Locally Targeted Results (FPs)
* IPs: Intermediate Pointers
* FPs: Final Pointers

Figure 2. Location-based personalized web search in smart phones

(i) Monotonically nondecreasing (ii) Monotonically nonincreasing (iii) Unimodal

Figure 4. Three types of quantifiers