Visual Interfaces for Improved Mobile Search

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ABSTRACT

The Mobile Web promises a new age of anytime, anywhere information access to billions of users across the globe. However, the Mobile Internet represents a challenging information access environment, particularly from a search standpoint. In this paper we present two visual interfaces for improved mobile search. First, we present *SearchBrowser*, a map-based interface that offers richer end-user interactions by taking into account important mobile contexts including location and time. Second, we consider the social context of mobile search and present *SocialSearchBrowser*; a proof-of-concept interface that incorporates social networking capabilities to improve the search and information discovery experience of mobile subscribers.

Author Keywords

Mobile Search, Search Interfaces, Social Search, Social Networking, Mobile Web, Context, Preferences, Location, Time

ACM Classification Keywords

H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval, H.5.2 [Information Interfaces and Presentation]: User Interfaces

INTRODUCTION

There are over 3.5 billion mobile subscribers worldwide[1] and with continued advances in devices, services and billing models, the number of subscribers venturing online via their mobile handsets is increasing. Thus the mobile space looks set to usher in a new age of anytime information access. However, the Mobile Internet represents a challenging information access environment, particularly from a search standpoint. Limited screen-space and restricted text-input and interaction capabilities exacerbate the shortcomings of modern Web search. To date most mobile search interfaces are simple adaptations of standard Web interfaces, where users are presented with a ranked list of results. For mobile search to succeed we need to think beyond simply query-based interfaces and towards interfaces that can offer richer interactions by taking into account important mobile contexts that have an impact on mobile users needs.

In this paper we focus on the mobile search interface and we offer on a more radical rethink of mobile search. It has always been our contention that mobile search differs significantly from Web search, not just because of the devices but also because people's information needs differ when mobile. Previously we examined the information access patterns of real mobile subscribers using log analysis techniques [6]. More recently, we investigated mobile information needs in-situ, examining the unique contextual factors that impact on user needs [5]. Our findings indicate that when users are mobile there is a clear location and temporal dependency in their information needs. Furthermore, we found that the needs that arise when mobile cannot always be answered by existing search engines, because existing search engines do not take key mobile contexts into account.

Based on the findings of these previous studies, we devised two new visual interfaces for mobile search, both designed to emphasise the importance of location, time and preferences as key elements of search context. Unlike traditional search interfaces, which require user input before providing information to end-users, our interfaces give mobile users interesting information from the beginning. Our approach is designed to change the mobile search paradigm. The interfaces present historical query, comment and result-selection data for users to navigate through on an interactive map-based interface. The rich user interface enables users to interact with the past activities of other users, execute searches, view past result-selections and filter queries based on context information. In short by presenting users with information about what others are searching for we believe we can offer an improved search experience.

This paper is organized as follows. In the following section we present some related work. Next, we describe *SearchBrowser*, a map-based interface that offers richer end-user

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[1]http://www.un.org/apps/news/story.asp?NewsID=28251&Cr=Telecommunication&Cr1

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interactions by taking into account important mobile contexts including location and time and we describe the results from a recent user study. Based on the outcomes of this evaluation and the findings from our diary study [5], we turn to the Social Web and explore the social context of search. In the final section of this paper we propose a proof-of-concept interface called *SocialSearchBrowser* that incorporates social networking capabilities to improve the search and information discovery experience of mobile subscribers.

RELATED WORK

The focus of this paper is on novel mobile search interfaces that utilize key mobile contexts. There has been a range of previous research that investigates improved search interfaces in the general Web space. Our current work combines work on exploratory search, mobile search and social search. As such we have identified three areas of related research:

Exploratory Search

Traditional approaches to Web search typically involve a user submitting a query via a search box and viewing a list of results. More recently, a new class of search has emerged, called *exploratory search* [14], which supports the exploration and discovery of information through both querying and browsing strategies. There have been a number of exploratory search systems developed to date. For example, Hearst presents *Tile-Bars* [9], a technique which uses the structure of text to provide a visualization aid to end-users. TileBars help users to visualize the document length, query term frequency and query term distribution, thus assisting in relevance assessments of documents. Yee et al. [15] presents an alternative interface for exploring large collections of images using hierarchical faceted metadata and dynamically generated query previews. While recent work by Alonso et al. [1] describes an interface that utilises timeline data to enable effective presentation and navigation of search results.

Mobile Search

Another area of research related to this paper concerns innovative approaches to mobile search interfaces. FaThumb [11] is a user interface designed for navigating through large data sets on mobile devices providing a more efficient means of mobile search. FaThumb uses faceted metadata navigation and selection as well as incremental text entry to narrow the results. A user evaluation demonstrated how the facet based navigation is faster for less specific queries.

Questions not Answers (QnA) [10] also provides an interesting alternative to the traditional search interface. Rather than examining how to provide high-quality search results, the QnA approach is to provide access to previous queries posted from the user's current location. This novel user interface displays queries made by other people in a given location using a map-based interface, providing users with an enriched sense of place. By clicking on the queries users can execute the displayed search. In a live user evaluation [2], users found the interface to be useful and they enjoyed the increased level of interaction the interface enabled.

Social Search

More recently researchers are investigating the social side to Web search. For example, Collaborative Web Search (CWS) involves utilising the search histories (i.e. queries and result-selections) of communities of like-minded individuals. In [7], Freyne et al. looks at integrating CWS with social browsing, i.e. leveraging past browsing behaviour of users to guide others to relevant web content, to produce an integrated social information access service. Preliminary results from a live user trial indicated that the use of social cues helps users to access relevant information in an easy and efficient manner.

Another approach is to exploit Web 2.0 technologies, specifically Web annotations, to improve Web search. The basic premise is that by allowing users to annotate search results and to share these annotations with others, the search experience can be improved. In [3], Boa et al. propose two novel algorithms, *SocialSimRank (SSR)* and *SocialPageRank (SPR)* to explore the role of social annotations on similarity ranking and static ranking respectively. Results from an evaluation using a del.icio.us dataset shows that both SSR and SPR could benefit Web search significantly.

Another related area of interest is *social search*. Social search in this context involves exploiting different forms of human judgements, ratings and interactions to improve the overall search experience. For example, Microsoft's *U Rank*[2], is a prototype search engine that allows people to edit, annotate and organise search results. U Rank enables users to collaborate with one another through sharing and recommendation of search results in easily accessible *lists*.

Most relevant to our current work is utilizing social networks to enhance search results and online interactions. In [8] Golbeck and Wasser introduce an application called *SocialBrowsing* which works by analyzing web page content and highlighting words or phrases which have some contextual social information. In [12], Mislove et al. present *PeerSpective*, an experimental prototype which exploits both the hyperlinks of the Web as well as the social links within communities of users to inform a new search result ranking approach. An evaluation of the PeerSpective search engine showed that it performs well in terms of disambiguation, ranking and serendipity of search results.

Our Proposal & Contributions

Our current work is similar in nature to the QnA approach. The QnA system essentially tags queries with a location. These queries are displayed on a map-based interface enabling users to visualise the search space. The QnA prototype does not, however, provide any means for a user to filter queries, other than by location. Given that the volume of queries at specific locations is likely to be quite high and there is no means to filter queries, the QnA prototype raises a new interface/presentation challenge. Furthermore, our prototypes focus on the social side to mobile search allowing users to interact with the result-selections and comments of other users. In the SocialSearchBrowsr application, we investigate this social context further by utilizing social

[2]http://research.microsoft.com/projects/urank/

networks for improved information access. We think this is a core area to address given the unique characteristics of the mobile space. Thus the core contributions of this paper are as follows: (1) we present SearchBrowser, a context-aware mobile search interface that enables *situated discovery* of information, (2) we describe a recent user evaluation of SearchBrowser and demonstrate some initial positive results and (3) we propose SocialSearchBrowser, an extension of SearchBrowser, which explores the social context of search by incorporating social networking to improve the information access experience of the end-user.

THE SEARCHBROWSER INTERFACE

The basic premise behind the *SearchBrowser* interface is that by allowing users to see what other users have been searching for and interacting with, we can improve the search experience. The interface utilises contextual information such as location and time to provide a unique experience. The interface provides mobile users with information more proactively, thus encouraging discovery of content. The prototype[3] consists of a text box that allows users to issue new queries and a small map centered at the user's current physical location. The map shows queries submitted by other users in that location and two sliders at the bottom of interface are used to filter the queries displayed on the map.

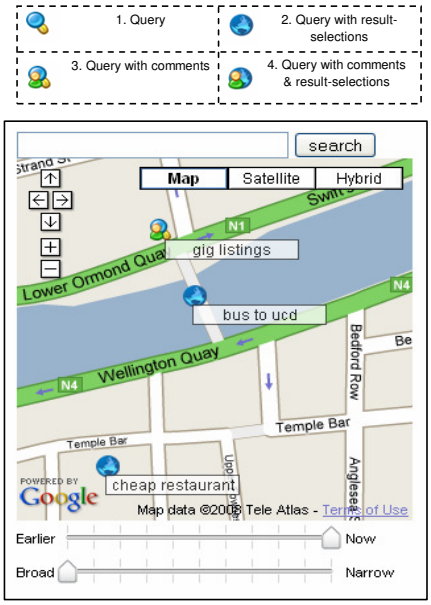
The Map Interface

When the user first initialises the application, he/she is shown a map centered at their current location (Figure 1). The map shows all *recent queries* entered by other users in that location. We refer to these queries as the *prime set*. The map is updated periodically so that newly entered queries are displayed. Queries submitted by other users, but without any result selections, are identified by a small magnifying glass with an associated label (See Figure 1 icon (1)), while queries that have resulted in the selection of at least one Web search result are identified by the small globe/Web icon with an associated label (See Figure 1 icon (2)). The label displays the actual query text. If a query or result-selection has a comment associated with it, the associated icon is augmented with a small user image. Comments can come in the form of answers, suggestions, tags, descriptions, general comments/remarks, etc. Queries with comments are shown in Figure 1 icons (3) and (4).

Search Histories

Clicking on the query icons/labels opens an information window/bubble (Figure 2), showing the query, the time the query was last executed and a link to execute the query in question. If the query lead to a result-selection the information window also displays the most recent result-selections. Furthermore, if the query has any comments associated with it, a link to view these comments is also shown (Figure 3 illustrates the comments facility). Users can choose to go directly

[3]The work presented in this paper builds upon earlier work presented in [4]. We have extended our previous work by: (1) enhancing the interface component of the SearchBrowser application, (2) by adding a comments feature in which users can add comments to queries and (3) by carrying out an initial user evaluation designed to test the basic utility of the interface.



SearchBrowser interface on startup

Figure 1. The SearchBrowser interface: shows queries, comments and result selections made by other users in a given location. Note the legend, which describes the interface icons, is shown for illustrative purposes only and is not shown to users of the system on startup.

to one of the listed URLs or to re-execute the query[4].

To help users distinguish between popular queries, the icon sizes of the queries change based on their *popularity*. We use a simple measure of popularity based on the number of times the query has been submitted and the amount of result-selections and comments associated with the query. Smaller icons indicate a low level of interactivity, while larger icons indicate a high level of interactivity.

Context Sliders

At the bottom of the interface there are two sliders. One slider represents *time* while the other slider represents *query similarity*. Users can manipulate the sliders to *adjust* the set of *prime queries* and to filter these queries. For example, users can adjust the time slider to go back in time and display queries submitted during different time periods. Thus rather than simply displaying queries submitted *now* (i.e. in the last couple of hours), users can view queries submitted over the entire day, yesterday, the last few days, last week, etc.

The same principle applies to the query similarity slider. However, instead of time, the query similarity slider filters by query term overlap. When a user accesses the application, the system automatically calculates the *similarity* between the user's queries and all other queries in the dataset. Moving the query similar slider, changes the similarity threshold and thus filters queries from the prime set. In the following section we describe our evaluation of SearchBrowser.

[4]Note that if a user chooses to re-execute a query they will receive a set of results from the standard Google search engine.

Figure 2. Clicking on a query opens an information window which shows the query, when the query was last executed, result-selections associated with the query and a link to view comments.

Figure 3. Choosing to view query comments shows a list of comments with information about when the comment was added.

EVALUATING SEARCHBROWSER

We had two main aims in carrying out an evaluation of the SearchBrowser interface. First, we wanted to assess the effectiveness of the interface, focusing on key features of the interface and their usefulness. Second, we wanted take the first steps to investigate the potential of the new interface to encourage discovery of new interesting content.

Dataset

To demonstrate the range of functionalities supported in the SearchBrowser application, we needed a source of queries, comments and result-selections as the basis of our dataset. To generate the seed queries, we manually extracted > 200 entries from the online WikiMapia service, focusing on entries with a latitude/longitude in the central Dublin, Ireland. *WikiMapia*[5] is a Web 2.0 application designed to encourage users to describe the world. WikiMapia allows users to mark areas on a Google map and describe those areas using titles, descriptions, tags, categories, images and links to external URLs. Given that each entry in WikiMapia includes rich descriptive information, along with an original creation date and a physical latitude/longitude value, it provided a good basis to generate seed user queries for our evaluation.

To generate realistic queries we then asked 3 different users to view the list of WikiMapia entries and to formulate a query for each[6]. This resulted in 444 generated queries which were then used as a basis for the prime dataset[7]. For each query, we extracted the associated WikiMapia entry, generated a random date and latitude/longitude within the chosen time period and given location boundary, i.e. central Dublin)[8]. Any URLs associated with the WikiMapia entry were used as the result-selection(s) and if the entry had tags associated with it, we used the corresponding title/name as the comment. The outcome was a set of time-stamped, geo-coded, query, comment and result-selection data.

Participants & Methodology

20 participants took part in the study, 18 male and 2 female. The participants comprised a mix of computer science staff and post-graduate students from UCD, ranging in age between 25 and 40 (average: 30, standard deviation: 4.23). 85% of users had some previous Mobile Internet experience, but most of these users (approximately 60%) accessed the Mobile Internet on an infrequent basis.

The participants carried out the experiment online using a standard Web browser. The Web browser emulated the *SearchBrowser* interface by using similar screen real-estate to an iPhone (320 x 480 pixels). Participants were asked to (1) to familiarise themselves with the interface for the first few minutes of the experiment and (2) to formulate and submit five queries of their own using the interface. We informed participants that the queries were open-ended, however, we did ask participants to bear in mind that the interface is designed for mobile devices and as such would be used while on-the-go. When generating their queries, we asked participants to try to think of things they might need/like to find out if mobile and in the location presented on the map. Before they were exposed to the interface the participants were presented with a description of the various features of the interface. At the end of the evaluation, users were presented with a post-task questionnaire designed to measure their subjective reactions to the interface[9].

Usage Results

[5]http://www.wikimapia.org

[6]Each participant was presented with the same list of WikiMapia entries and participants were instructed to generate queries for as many entries as possible out of the list of > 200 entries.

[7]We are aware that artificially generating queries in this manner is a limitation of this study. However, without deploying SearchBrowser, it is impossible to obtain a realistic source of queries. For users to evaluate the application we needed to be able to show them a sample of queries, comments and result-selections and WikiMapia offers a rich set of geo-coded data as the basis.

[8]A note on random location values: in a realistic setting it is unlikely that a user will always submit a query related to an exact physical location. For example, if the user wants to know where they can find a coffee shop on a particular street, the query could be generated anywhere along that street or within close vicinity to that street. Therefore, we opted to generate a random latitude/longitude within close vicinity to the actual latitude/longitude value.

[9]This study allowed us to gather interesting feedback about the interface and it's overall usability. We are aware that the evaluation is limited in that is does not take place in a mobile setting, however, we feel that the evaluation in it's current form still yields some interesting results and represents an important first step in our ongoing work in the mobile search space.

In this section we focus on the quantitative results by exploring the user interactions with the map-based interface as well as general usage statistics.

Interactions with the Map Interface

Using click-thru and mouse-over data we were able to analyse what features of the map and user interface the participants interacted with. Although the level and type of interaction with the SearchBrowser interface is likely to be different in a real mobile setting, we were still interested in examining interactions with the map so that we could gather some insights into which features of the current user interface participants were drawn too. Overall we found a high degree of interactivity from end users. All users interacted with the map based interface using both zoom and drag functions to navigate. All users clicked on either a query or result selection marker and opened an information window bubble. We found that 95% of users clicked on the query markers while 75% of users clicked on the result-selection markers. We also found a high degree of interactivity with the various markers/query icons, with mouseover events tracked for the vast majority of users. Thus, users did interact with the queries and past result-selections of other users.

We found that most users selected search results within the SearchBrowser application. However, only 10% of users chose to click on a URL in the result-selection bubbles, thus indicating a low level of interactivity with the past result-selections of other users. Our later analyses indicate that poor search results may have been the main cause for such a low level of interaction. We also found that 70% of users chose to view the comments of other users, but less than 50% chose to generate comments of their own[10].

Search Usage

The results so far demonstrate that from an interactivity standpoint, all users engaged with the SearchBrowser interface. Table 1 presents some basic usage statistics. The participants generated almost 300 queries, 126 of which were newly generated queries (i.e. submitted via the search box and not through interactions with queries presented on the map interface). Interestingly we find that 45% of all newly submitted queries by participants lead to at least one result-selection. This represents a significant increase on the success rates found in [6] in which only 11% of mobile queries lead to the selection of at least one search result.

Questionnaire Results

In this section we examine the participants' subjective reactions to SearchBrowser. At the end of the evaluation, users were presented with a post-evaluation survey. The survey was designed using a combination of questions from well-established usability questionnaires such as QUIS[11] and the IBM Computer Usability Satisfaction Questionnaires[12]. We also included some more detailed usability and user-acceptance questions focusing on key aspects of the SearchBrowser interface. Participants rated their agreement with various statements on a 7-point anchored likert scale[13], with a rating of 1 indicating "strongly disagree", a rating of 7 indicating "strongly agree", while a rating of 4 indicates "neutral". The survey questions fell into three categories: (1) overall satisfaction, (2) application features and (3) user interface (UI). A full list of questions can be found in the appendix.

Measure	# Q	# Q_n	# C	# C_{qn}	# CM
Total	297	126	76	57	23
Mean (per-user)	14.9	6.3	3.8	2.9	1.2
Min	5	5	0	0	0
Max	84	13	9	6	14
SD	17.4	1.9	2.6	2	3.1
# Users	20	20	16	16	7
% Users	100	100	80	80	35

Table 1. Basic usage statistics, where Q: queries, Q_n: newly submitted participant queries, C: click-thrus, C_{qn}: click-thrus generated from newly submitted participant queries, CM: comments.

Overall Satisfaction

Q	**M1**	**SD**	**M2**	**M3**	**Frequency Count**						
					1	2	3	4	5	6	7
1	4.50	1.47	5	5	1	0	5	2	7	4	1
2	5.85	1.35	6	7	0	1	0	2	3	6	8
3	5.55	1.28	6	5	0	1	0	2	6	6	5
4	5.85	1.14	6	7	0	0	0	3	5	4	8
5	3.70	1.66	4	4	1	5	3	6	1	3	1
6	4.00	2.00	4	4	2	3	4	4	2	1	4
7	5.65	1.27	6	6	0	1	0	2	4	8	5
8	5.30	1.42	5	5	0	1	0	5	6	2	6

Table 2. Results for the user satisfaction section of the survey. Q is the question number, M1 is the mean, M2 is the median, M3 is the mode and SD is standard deviation.

The list of satisfaction questions can be found in Table 7 in the Appendix. Overall, the participants' subjective assessment of satisfaction with the application was positive, with an average response of 5.05. Participants found the application easy to use (q2=5.85) and easy to learn (q4=5.85). They found performing tasks to be straightforward (q7=5.65) and in general felt that they could imagine using the application while mobile (q8=5.3). However, users were unbiased in their rating of statement 6 regarding expected functions and capabilities, and we found the general satisfaction rating assigned by users was more neutral (q1=4.5). We attribute this to one key issue: users found it somewhat difficult to find the information they needed/wanted (q5=3.7). The goal of this evaluation was not to assess the search result quality, but rather the interfaces effectiveness and in this evaluation we were limited by the underlying search engine. We used the Google search API for the search component of the application. We attempted to *localise* the queries by appending the

[10] In most social websites, the majority of users don't actively participate in the generation of new content. In an analysis from Yahoo! Groups, 1% of users actively create new content, 10% of users actively contribute to such content (e.g. replying to a blog post) while 100% of users benefit by reading/viewing the content generated by the others. See http://www.elatable.com/blog/?p=5.

[11] Questionnaire for User Interface Satisfaction: http://hcibib.org/perlman/question.cgi?form=QUIS

[12] http://drjim.0catch.com/usabqtr.pdf

[13] http://en.wikipedia.org/wiki/Likert_scale

terms *Dublin* and *Ireland* to participant queries before issuing them to Google. However, one of the main comments by participants was that the search results were not as localised as they expected/wanted.

Application Features

Q	M1	SD	M2	M3	Frequency Count						
					1	2	3	4	5	6	7
1	4.25	1.48	4.0	4	0	3	2	8	3	2	2
2	4.40	1.54	4.5	5	0	2	5	3	5	3	2
3	4.30	1.66	5.0	5	1	3	2	3	6	4	1
4	3.75	1.77	3.5	6	2	4	4	2	3	5	0
5	3.55	1.70	3.5	5	3	3	4	3	4	3	0
6	4.20	1.94	5.0	6	2	4	1	2	4	6	1
7	5.25	1.59	5.5	7	0	2	1	2	5	5	5
8	5.85	0.99	6.0	6	0	0	0	2	5	7	6
9	5.40	1.67	6.0	7	0	2	1	2	4	4	7
10	5.60	1.19	5.5	5	0	0	1	2	7	4	6
11	3.80	1.67	4.0	5	2	4	2	3	6	3	0
12	4.45	1.39	5.0	5	1	0	4	4	7	3	1
13	4.40	1.19	4.5	5	0	0	6	4	7	2	1
14	3.95	1.90	4.0	4	3	2	2	6	2	3	2
15	4.10	1.74	4.5	5	2	2	3	3	7	1	2
16	3.55	1.85	4.0	2	3	5	1	4	4	2	1
17	3.60	1.98	4.5	5	5	3	0	2	8	1	1
18	1.55	0.94	1.0	1	13	5	0	2	0	0	0
19	3.45	2.14	4.0	1	7	1	1	3	4	3	1
20	4.85	1.95	5.0	7	0	3	4	1	4	1	7
21	5.85	1.23	6.0	7	0	0	1	2	4	5	8
22	5.10	2.22	6.0	7	1	4	1	1	0	5	8
23	4.15	1.93	4.5	2	1	5	2	2	5	2	3
24	4.90	1.92	5.0	7	2	0	3	2	4	4	5
25	5.05	1.70	5.0	7	0	2	1	5	5	0	7

Table 3. Results for the features section of the survey.

The list of feature questions can be found in Table 5 in the Appendix. We found the majority of users were almost unbiased in their responses to the first set of questions regarding the query feature. For example, we found that in general participants didn't find that they interacted with queries frequently (q5=3.55) and they were unsure as to whether other people's queries helped them form their own queries (q6=4.2). However, users did rate statements 7, 8 and 9 positively, indicating that the queries provided an understanding of the type of information that is relevant to the location. Users liked the ability to browse other user queries. Furthermore, they thought it was an interesting way to discover new information (q8=5.85) and it helped them learn about other people in the area (q9=5.4). One of the main aims of the evaluation was to assess whether users liked the exploratory interface provided by SearchBrowser and these initial results indicate that this may be the case.

Although participants found the ability to view result-selections useful (q11=5.60), they found they did not interact frequently with the result-selections of others (q11=3.8) and were neutral in their opinion as to whether the result-selections of other users provided them with additional information about the query (q12=4.45). We attribute this finding to the poor quality of the search results presented to users. It is likely that the ratings for such features would increase if the search results returned improved.

The comments feature resulted in a relatively neutral rating on average (q14=3.95, q15=4.10). In fact we find that participants were quite divided in their opinion on the usefulness of the comments feature. For example, when asked if the comments feature helped them to learn more about the query, we find that 10 users agreed, 3 users were unbiased and a further 7 users disagreed (q15). Interestingly we found that users were more in agreement that they added comments to their own queries (q19=3.45), rather than adding comments to other people's queries (q18=1.55). After examining the remarks of participants about the comments feature, we found that some users were not clear on what constitutes a comment. This is something we look at improving in the SocialSearchBrowser application.

User ratings for the two slider features were generally positive. We found that 12 users (60%) assigned a positive rating when asked if the time slider is useful, while 13 of the users (65%) liked being able to filter queries based on time. Users found the *time slider* more intuitive and as such interacted with the time slider more frequently. Reaction to the query similarity slider was less positive overall. For example, users were quite neutral when asked if the query similarity slider was useful (q23=4.15), however they were quite positive when asked if they liked being able to filter queries based on query similarity (q25=5.05). Interestingly, we find that when we examine the frequency count for each of the 7 ratings assigned to the slider questions, the most popular rating is *strongly agree* (score of 7), indicating that the users who did like the slider features found them very useful.

Overall the SearchBrowser features were well-received by participants, with the queries and time slider features rated most positively out of the five feature sets. The results indicate that with some straightforward improvements, the remaining features (result-selections, comments and query similarity slider) could become more effective.

User Interface

The list of user interface questions can be found in Table 6 in the Appendix. Most of the participants were satisfied with the interface (q1=5.05), found the interface pleasant (q2=5.9), intuitive (q17=5.9) and liked interacting with the interface (q3=5.75). Users also found the interface easy to interact with (q14=6.2). Furthermore, users were able to easily explore the various features of the map (q16=5.9) indicating that perhaps such an interface would work well as a information discovery tool in the mobile space. Users noticed the queries on the map (q4=6.45), enjoyed the icons used to represent queries (q5=5.45) and were somewhat positive as to the intuitiveness of the query icons (q6=4.85).

When examining the two sliders, we find that users rated the time slider more highly, indicating that they noticed the time slider (q7=6.45), they found it intuitive (q8=6.3) and they liked the time slider (q9=6.3). The ratings assigned to

similar statements for the query similarity slider, although positive, leaned more towards an unbiased rating. As mentioned in previous sections, we included the time and query similarity sliders in the SearchBrowser application so that users could quickly and easily filter the set of queries displayed on the map. However, even with such features, we find at times that the interface became cluttered with information (q15=4.4) thus making it more difficult to read the information presented (q13=4.95).

Overall we found the response to the user interface by participants was very positive, with the majority of users assigning top marks to the vast majority of statements, thus indicating that the current SearchBrowser interface design is both usable and aesthetically pleasing.

Q	M1	SD	M2	M3	Frequency Count						
					1	2	3	4	5	6	7
1	5.05	1.76	5.5	6	1	1	3	0	5	6	4
2	5.90	1.41	6.5	7	0	1	0	2	4	3	10
3	5.75	1.16	6.0	6	0	0	1	2	4	7	6
4	6.45	1.00	7.0	7	0	0	1	0	1	5	13
5	5.45	2.09	6.5	7	2	0	3	0	2	3	10
6	4.85	2.41	6.0	7	2	4	1	1	1	2	9
7	6.45	1.19	7.0	7	0	1	0	0	1	4	14
8	6.30	1.22	7.0	7	0	1	0	0	2	5	12
9	5.40	2.04	6.5	7	1	1	3	2	0	3	10
10	4.65	2.52	6.0	7	5	1	0	2	1	4	7
11	4.65	2.11	5.0	7	3	1	1	3	4	3	5
12	4.60	2.04	5.0	7	3	0	2	4	4	2	5
13	4.95	1.99	6.0	6	1	3	1	2	2	6	5
14	6.20	0.89	6.0	7	0	0	0	1	3	7	9
15	4.40	2.14	4.5	7	3	2	1	4	2	4	4
16	5.90	0.97	6.0	6	0	0	0	2	4	8	6
17	5.90	0.97	6.0	6	0	0	0	2	4	8	6

Table 4. Results for the user interface section of the survey.

As well as asking users to rate their perceptions of the SearchBrowser application on the 7-point likert scale, we also asked users some more general freeform questions. 90% of users said they would use the SearchBrowser application if the service was easily/readily available. When asked under what circumstances would they use such an application, participants submitted a range of responses including, if there were in an unknown physical place (e.g. a new city), to find information about local services/products, to keep up-to-date with current events and finally to find directional/travel-related information. Interestingly, users also commented on the social aspect of the application, indicating that the social side to the SearchBrowser application could be very useful for *query recommendations*.

Overall the results of the evaluation were positive. The SearchBrowser study represented an important first step in evaluating this type of interface and it provided us with some valuable feedback regarding the interface components and the supported interactions. However, the evaluation results also encouraged us to re-think some elements of the prototype. Furthermore, results from a recent diary study of mobile information needs indicate that mobile users seek fresh content that is location and time specific and is influenced by social context [5]. Although existing search giants attempt to provide some solutions — for example, Google's mobile search facility utilizes a users default location in order to contextual search results[14] — these solutions don't go far enough.

One of the unique features of the SearchBrowser interface is that it provides a *comments* facility which allows users to add comments, tags, answers and suggestions to the queries submitted by other users. The key idea behind this facility is that it allows users to provide helpful information to assist other users with their information needs, thus embracing the social side to mobile search. Although the comments feature represented a simply first step at utilizing people-power to enhance the search experience of mobile users, we believe that there are a number of opportunities in this research space. In particular, we think that there is great potential in utilising a users social network as a source of valuable query answers, comments, etc. Furthermore, incorporating a users social network into the mobile interface would allow some novel and interesting filtering methods based on 'friend' queries. Thus we have developed a prototype called *SocialSearchBrowser* which allows users to execute queries in various physical locations but also enables *friends* of the current user to *answer* these queries in real-time. In the following section we describe SocialSearchBrowser in more detail.

SOCIALSEARCHBROWSER

Human beings, by their nature are social creatures. We live by communicating with others, building relationships and forming friendships. In fact, many people view the mobile phone as a *social* communications device, that is, a device which can be used to stay in contact with friends and family [13]. Online social networking sites such as Facebook and MySpace have experienced a huge increase in usage in recent times, with more and more users seeking novel ways of interacting with their friends and family[15]. And in the near future it is likely that mobile phones will be used as the first port of call in accessing these online social networks.

The SocialSearchBrowser is made up of two components. The first component is a map-based interface that works in a similar way to the previously discussed SearchBrowser application. The second component is a Facebook application. The interface consists of a text box that allows users to issue queries, a small map centered at the user's current physical location which displays all queries executed in that location and three sliders at the bottom of the interface for filtering the set of queries displayed (See Figure 4). We have introduced a new *social* slider which allows users to show queries submitted by *everyone* or to display only queries submitted by *friends*. Manipulating the social slider changes the *level of friendship* threshold and as such updates the queries displayed on the map. The premise behind this slider is that users are likely to be interested in the queries and interac-

[14]http://www.google.com/m

[15]The latest statistics from Facebook highlight that there is currently 150 million active users worldwide (Jan 2009). See: http://www.facebook.com/press/info.php?statistics

tions their friends have participated in.

The Facebook application comprises of an information page showing all queries submitted through the SocialSearchBrowser interface. The information page lists the query submitted, the name of the user who submitted the query, the location of the user and a timestamp indicating when the query was submitted (See Figure 5). Clicking on the query opens a more detailed information page (See Figure 6). The detailed page shows relevant query details but also displays a Google map of where the user was at the time the query was executed. It also shows a list of any answers/comments submitted for the query and a form for entering new answers/comments. In this way Facebook users can see what queries their friends have executed on the go, where and when their friends executed these queries and any answers provided to these queries. To envisage how the SocialSearchBrowser would work, imagine the following scenarios:

Figure 4. The new SocialSearchBrowser interfaces which allows mobile users to filter the set of queries to display queries entered by friends.

Amy is wandering around Plaza de Catalunya in Barcelona as part of her weekend away in Spain. She wants to know where she can find a nice restaurant that serves tapas but she wants to avoid touristy places. Amy takes out her iPhone, opens the browser and connects to SocialSearchBrowser. Amy is presented with a map centered at her current location. The map displays other queries and user interactions that have taken place in her current location. Amy is able to get an idea of the types of needs that arose from other mobile users

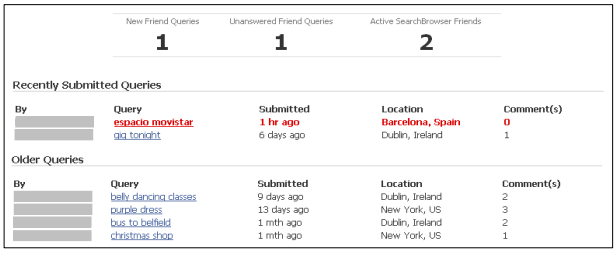


Figure 5. Facebook application showing the initial query list page.

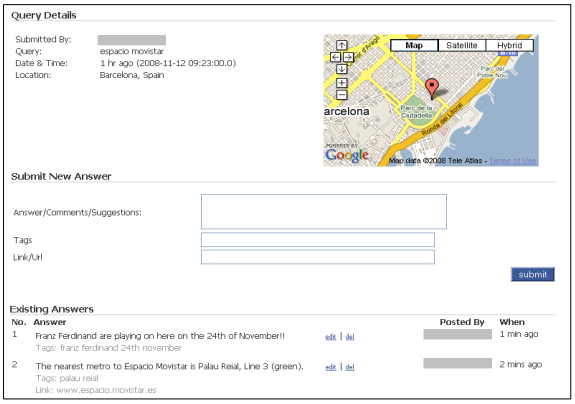


Figure 6. Facebook application showing the answer details page.

in this location. Amy doesn't see any queries on the map related to tapas so she decides to submit her own query. Thus, Amy enters the query "good tapas" via the SocialSearchBrowser interface. Amy is presented with a localized list of Web search results for her query. At the same time a notification is sent to Amy's facebook friends indicating that Amy is in Barcelona and that she'd like some help with a query. A few minutes later Amy is alerted that one of her friends has submitted an answer to her query. Amy returns to the map, clicks on her query and is shown the answer(s) submitted by her friend(s). Perfect, now Amy knows exactly where to go for great tapas!

David is in the middle of Dublin city center, sipping on a coffee and is thinking about what to do this weekend with friends. He takes out his iPhone, opens the browser and connects to SocialSearchBrowser. David is presented with a map centered at his current physical location. David is able to see straight away that other users have entered queries like "coffee to go" and "salsa classes" in this location. David decides he wants to explore what else other people in this location have been interested in. He moves the temporal slider towards the earlier marker and the map is updated with lots of different queries entered in this location. David see's lots of queries related to comedy events. David then uses the social filter to show only queries submitted by his friends and he notices that his friend Tony was looking for tickets to see a comedy show last week. David decides to call Tony to see if he'd like to go to a comedy show this weekend.

Ideally, when queries are submitted via SocialSearchBrowser, a user's friends will be online and will be able to offer help immediately. This scenario could also be extended to allow *anyone* to answer queries, but in this case, answers generated by close friends of the user would be rated higher. Other social factors could also be explored. For example, in the current prototype we include a social slider for filtering queries so that only queries generated by friends are displayed. We could also investigate filtering friend locations, i.e the set of locations where your friends executed queries, etc.

Thus, SocialSearchBrowser provides an alternative means of mobile search and information discovery, taking into account key mobile contexts such as location and time, while exploiting the social context of search. Users are encouraged to discover new, interesting content and perhaps new, interesting places. The new prototype utilizes a users social network to improve the information access experience, allowing friends to provide helpful information through real-time query answering. Furthermore the application enables a new form of social discovery by allowing friends to share queries and online interactions while mobile.

CONCLUSIONS

Mobile information access is challenging, particularly from a search perspective. In this paper we described two new interfaces for improving mobile search and discovery. The first interface, *SearchBrowser*, presents users with historical query, comment and result-selection data on a rich map-based. The application takes important mobile contexts into account such as location and time. Results of an initial user trial were positive and demonstrated that the current interface design is easy to use, easy to learn and aesthetically pleasing to end-users. Based on user feedback from this evaluation and results of a recent diary study of mobile information needs, we developed an extended proof-of-concept prototype, that explores the social context of mobile search. SocialSearchBrowser is an innovative interface that incorporates mobile contexts with social networking capabilities to improve the search and information discovery experience of mobile subscribers. SocialSearchBrowser allows friends to provide help to mobile users in the form of answers, comments, suggestions, links and tags, through a Facebook application. Furthermore, the interface incorporates a social filter which enables mobile users to filter the set of queries displayed to show only friend queries, helping to visualise friend queries and interactions.

We are currently investigating a number of different areas relating to the prototype. Firstly, we are in the process of implementing a fully functional working prototype which we plan to test and evaluate with real users in a live mobile field study. We have also identified a number of interesting future directions that explore the social context of search in more detail. We'd like to consider other social filtering approaches. For example, we could show popular friend queries and allow users to visualize the most common locations in which friends have had previous mobile information needs. We could also exploit social networks to provide personalized query and location recommendations. For example, a mobile user might be interested to learn about a new street in their city where a number of their friends have submitted previous mobile queries. We're also interested in the automatic identification of 'close friends' vs 'not so close friends', based on facebook activity, presence in mobile phone contacts and other informative resources.

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No.	Question	Type
1	I found other people's queries useful	LK
2	I found other people's queries informative	LK
3	I found other people's queries intriguing	LK
4	I found other people's queries distracting	LK
5	I interacted with other people's queries	LK
6	I found that other people's queries helped me form my own queries	LK
7	Many of the queries displayed helped me to understand the sort of information that was relevant to the location being browsed	LK
8	The ability to browse other people's queries is an interesting way to discover new information.	LK
9	The queries helped me to learn about other people in the area, their needs and preferences	LK
10	The ability to view other people's past result-selections is useful	LK
11	I interacted with other people's past result-selections	LK
12	The result-selection feature provided me with additional information about the query	LK
13	The result-selection feature helped me find answers to the queries	LK
14	I found the comments feature useful	LK
15	The comments associated with a query helped me learn more about the query	LK
16	The comments associated with a query helped me find answers to the query	LK
17	I viewed other people's comments	LK
18	I added comments to other people's queries	LK
19	I added comments to my own queries	LK
20	I found the time slider useful	LK
21	I interacted with the time slider	LK
22	I liked being able to filter the queries displayed on the map based on time	LK
23	I found the preference slider useful	LK
24	I interacted with the preference slider	LK
25	I liked being able to filter the queries displayed on the map based on query similarity	LK

Table 5. List of features questions presented to end-users. (LK = 7-point likert scale).

No.	Question	Type
1	Overall, I am satisfied with the search browser interface	LK
2	The interface of the search browser application was pleasant	LK
3	I liked using the interface of the search browser application	LK
4	I noticed the queries on the map	LK
5	I liked the query icons	LK
6	I found the query icons intuitive	LK
7	I noticed the time slider	LK
8	I found the time slider intuitive	LK
9	I liked the time slider	LK
10	I noticed the query similarity slider	LK
11	I found the query similarity slider intuitive	LK
12	I liked the query similarity slider	LK
13	I was able to easily read information on the interface	LK
14	It was easy to interact with the interface	LK
15	The organization of information on the map was clear	LK
16	I was able to easily explore the various map features	LK
17	The interface was intuitive	LK

Table 6. List of interface questions presented to end-users. (LK = 7-point likert scale).

No.	Question	Type
1	Overall, I am satisfied with the search browser application	LK
2	It was simple to use the application	LK
3	I felt comfortable using the application	LK
4	It was easy to learn to use the application	LK
5	It was easy to find the information I needed	LK
6	The application had all the functions and capabilities I expect it to have	LK
7	Performing tasks is straightforward	LK
8	I could imagine using this type of application when out and about.	LK
9	Leaving cost aside, would you use the search browser application if the service was easily/readily available?	Y/N
10	What circumstances do you think you might find the search browser application useful?	F
11	What did you like about the search browser application?	F
12	What if anything did you find frustrating or unappealing about the search browser application?	F
13	How could we make the search browser application more useful for you?	F

Table 7. List of general satisfaction questions presented to end-users. (LK = 7-point likert scale, F = freeform, Y/N = Yes/No).