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A Preliminary Contextual Analysis of the Web Query Process

Abstract

In contrast with the significant quantitative analyses of large Web search transaction logs, in this paper, we use a contextual interview approach to understand when queries are used, and how they are formulated and reformulated in Web searching. This work is part of a larger study that aims to identify ways to build more supportive Web search interfaces. Analysis is based on the coding of an initial set of 24 semi-structured interviews that took place while participants narrated a screen capture video of their Web query searches in the domains of research and medicine. Results indicate that users rely heavily on experimentation, their knowledge of the Web, and information gathered throughout the search process to formulate queries.

Introduction

The query has long been the individual's primary point of access in information retrieval systems, and continues to be the main approach to information seeking on the Web. Yet, Web search engines are fronted by increasingly minimalist search interfaces that provide little scope or support for the user searching process. Indeed to date little research has addressed the search interface problem as noted by Toms and Bartlett (2001) who attempted a literature review in this area. Without the benefit of human intermediaries skilled in eliciting the information need from the user and in designing a well-formed query and search strategy, today's Web user must negotiate the information seeking process directly with the search engine.

As a first step towards designing more supportive search interfaces, the research reported here uses contextual interview data to understand one aspect of Web searching – the query process used by people in interaction with a search engine. The questions guiding this analysis are:

- What factors shape the decision to use a query (instead of a directory)?
- How are queries formulated?
- When and how are queries reformulated within the search process?

Related Literature

Web queries represent a variation of the expressed information need that has been studied in many IR contexts. Much of this research has pointed to the complexities and challenges of effective search query formulation. Taylor (1968) identified a process by which a visceral, pre-conceptual information need gradually becomes formalized, and eventually is crystallized into a search expression that can be entered in an IR system. Taylor represents this search expression as a compromised form of the original need, which the search intermediary must then rediscover through negotiation. Ingwersen

(1982) provides empirical support for Taylor's hypothesis, finding a tendency to simplify even well defined information needs when expressing search requests to intermediaries. He notes that this "label effect" strips the information need of its work task and underlying problem context, which the intermediary must try to identify. Belkin, Oddy and Brooks (1982) identified the difficulty of formulating queries in the absence of knowledge about a topic, and in the anomalous states of knowledge (ASK) research, sought to sidestep this problematic stage of query formulation by deriving "images" of information needs from detailed problem statements.

In early research, Saracevic (1978, 1980) takes an analytical rather than contextual approach to search queries by suggesting a framework for the analysis of questions. He classifies IR query issues into three categories: semantic (meaning), syntactic (form) and pragmatic (context), and develops a range of query analysis approaches based on these categories. This analytical approach has been followed up in other studies of queries as textual artifacts, notably in recent transaction log studies of Web queries (Jansen et al, 1998; Silverstein et al, 1999). This literature characterizes the typical Web query as just over two terms in length and primarily composed of noun phrases and indicates that under 20% of Web queries employ complex syntax or Boolean operators, and over 60% of search sessions use one query only. These transaction log studies provide an important quantitative basis for understanding Web searching, but leave many questions unanswered as to the motivations, needs and tactics of Web searchers

Empirical studies of the search process can increase our understanding of how and why people use queries. For example, research on how query terms are selected (Fidel (1991a, 1991b, 1991c), and the sources of query terms (Spink & Saracevic, 1997) provide valuable insights into the issues involved in query formulation, however, these studies are of expert searchers in a commercial online searching environment. We know that expert searchers develop and use queries differently (and more effectively) than non-experts (Lucas & Topi, 2002; Holscher & Strube, 2000, Lazonder, Biemans & Woepreis, 2000). Furthermore, Web searching studies have shown that Web queries are distinct from queries in other types of online searching (Jansen & Pooch, 2000). There is a significant body of Web searching research available, as reviewed by Hsieh-Yee (2000), and many of these studies report quantitative data on queries, but very few report how users experience that process. One notable exception that shows promise is the study by Wang, Hawk & Tenopir (2000). Their preliminary analysis of a rich contextual view of the search process has promising results: users had difficulty forming effective mental models of the Web space, which hindered their ability to search.

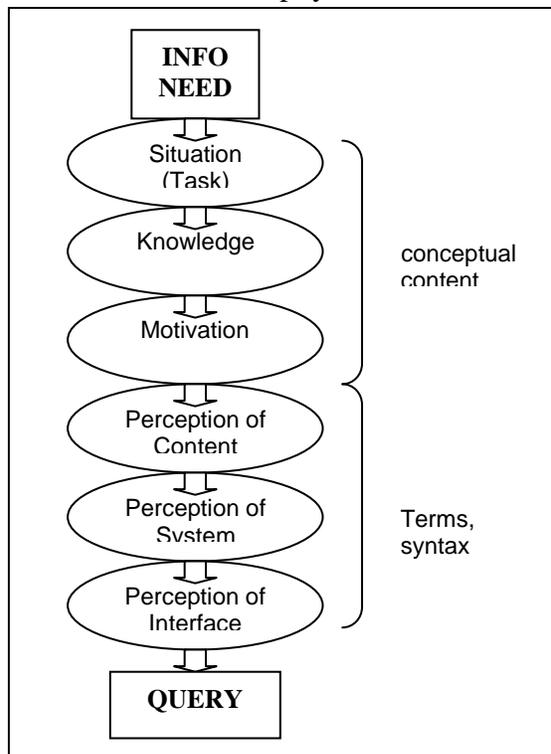
Models

Models of interactive IR have been developed by Saracevic (1996) and Ingwersen (1992, 1996). Spink (1997) incorporated the cyclical nature of the feedback loop to this model, and the model continues to be developed and adapted to the Web environment (Wang, Hawk & Tenopir, 2000). This section will outline an approach to Web querying that is informed by these models. Information retrieval can be viewed as a process of triadic interaction between the user, the system and the information content (Toms, 1997) that

can also be viewed from a cognitive perspective (Ingwersen, 1996). IR is a dynamic, iterative and essentially cognitive process, closely related to processes of communication. Interaction between the elements in this system is facilitated by the user interface, which plays a complex role as the representative and interpreter of the system and its content for the user. In this interaction, the search query is the user's primary means of communication with the system and the content that is being queried. If queries are the *lingua franca* in an IR system, then they are shaped to some extent by the same complex factors that shape language and communication in general:

- Situation - context of the discussion, i.e., work, home
- Topic - the subject that is being discussed
- Participants - the experience, ability and interests of the speaker
- Motivation - the participants' emotional state and impetus
- Perception of other - what the speaker thinks the other person knows and can understand
- Communication System - the common language being used
- Process - changes in the course of discussion of all or any of the above

These factors are similar to Saracevic's (1996) types of relevance (system, topical, situational, motivational, cognitive) and Wang, Hawk & Tenopir's (2000) factors that affect search behaviour (situational, cognitive, affective, and physical). In the query process, these factors act as query filters that operate within the cognitive space of the searcher (Figure 1). The top three filters represent factors that the user brings to the system, and which have a more direct influence on the conceptual content of the query. These include the physical and task environment of the searcher, the searcher's



motivation and mood, and the searcher's knowledge and ability on various levels: topical, search related, and language. The lower three filters have a more direct impact on the final form of the query, including the terms and syntax used. These filters represent the searchers' perceptions and mental models of the other elements in the system, which may be influenced by the interface, or by prior training or experience.

If we present IR in a more explicitly process-oriented way (Figure 2), we can see that the query filters, and by extension successive queries, are influenced through exposure to information resources and system feedback, as well as by external factors in the searching situation, such as noise, time constraints, etc. In Web searching, the process of querying includes the decision to employ a query, rather than browsing through a Web directory, going

Figure 1: Query Filters

directly to a known URL, or searching in some other way. This decision is implicit in the model, and seems to be influenced by the same factors that shape queries.

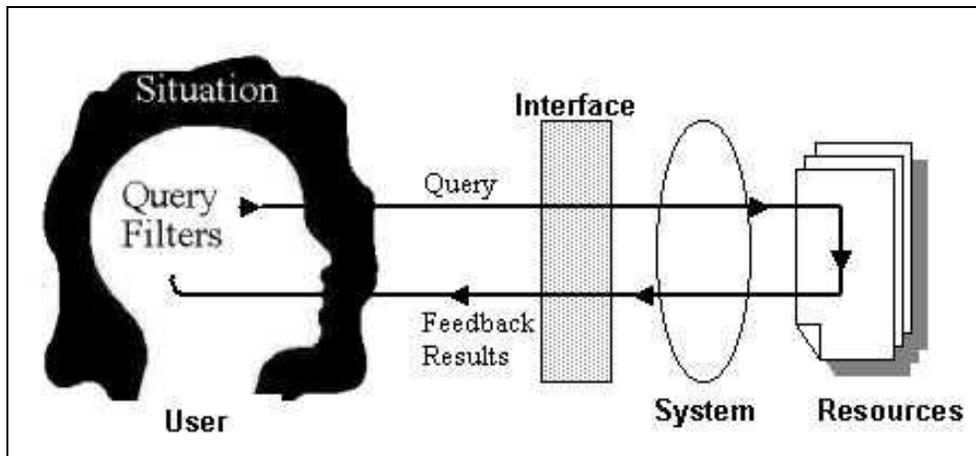


Figure 2: The Query Process

Methods

The data analyzed in this paper was collected for a larger study (Toms et. al, 2001) that is examining the search process holistically so that we can create more support for the search process at the interface level. The methods (below) have been summarized; a fuller description can be found in Toms et al. (2001).

Participants

Forty-eight participants (29 women and 19 men) ranged in age from 18-20 to over 65 years; 80% were under 35. Most had university level education, mainly at the bachelor (38%) or masters (30%) level, predominantly from the humanities or social sciences. All had used the Web, but none had taken professional search courses.

Search Interface

Participants interacted with a custom-designed search interface, which accessed the Google search engine. The interface contained both the search box/button and the Google directory categories. Beyond the first page, the standard Google interface screens were retained.

Procedure

The participants were recruited in August and September of 2001. Each participant was given four search tasks, one from each of Medical, Research, Travel and Shopping. Two of the four tasks contained specific questions; the other two contained questions in which the participant was required to fill in the blank with a topic of personal interest. We used a modified latin squares method to distribute the questions among the participants. Participants could use either the query box or the categories to do the search and could take up to 15 minutes to do the search.

Although multiple types of data were collected in the course of this experiment, the data reported on in this paper comes primarily from the semi-structured contextual interviews that took place following each completed search, while a screen capture video of the search was replaying.

Data Analysis

For this analysis, we coded 24 interviews from different participants who had used a query in the Research and Medicine domains. We selected these domains because our initial analysis of the data (Toms et al, 2001) showed similarities between the ways that searches were conducted in these two domains when compared with searches in Shopping and Travel domains. Those who responded to the search by using the directory or by using a mixed directory-query method regardless of domain have not been included. This analysis focuses on the habitual query users.

The interview data was professionally transcribed and was analyzed using an inductive and iterative process of developing codes for the interviews. The general framework for interview coding was based on the search states: task, search, hitlist, and Website, and the standard interview questions. However, as the interviews were semi-structured, and were shaped primarily by the video playback of the search, there was substantial variation among the interviews.

The development of codes was based on three rounds of inductive tagging and coding of small sets of 8-10 interviews. In each round the codes were compared with those from the previous set, and refined and revised based on input from both researchers. The final set of 70 individual codes were applied in layers to the interviews, in order to identify: actions and tactics employed, factors that influenced decision points, problems and obstacles encountered, and attitudes to and perceptions of Web searching.

Results and Analysis

From our analysis of the codes, we responded to the three questions driving this analysis: the decision to query, the formulation of queries, and the process of reformulating queries.

Decision to Query

Participants could choose to use a query box or select from the directory in their interaction with the Web search engine. Overall, they initiated 67% of the 192 searches with queries, and used a query at some later stage in the search in a further 20%. Clearly, the query was the more common choice, but the directory was used as an alternate approach. As indicated, we have focused on the habitual query generators in the analysis reported here.

For most of the participants in the smaller sample of query-based searches under analysis here, the decision to use a query rather than the directory was based on the fact that this is their normal, habitual approach to searching. It is what they do, "99% of the time," (P24-13) as more than one person noted. These users perceive query searching to be superior in some general way to directory searching, and they do not re-evaluate the decision each

time they begin a search. This preference for query searching seems to be based on ease of use and image, rather than content. Indeed, very few users seemed to be aware that the content of a directory is different than that of a search engine. Most of these habitual query users had negative impressions of using the directory, as tedious and time consuming: "it's too big, and you go on, go on, go, on..." (P09-42) or "you keep clicking and clicking" (16-44) . Metaphors used for the directory include "hunting" and "weeding," both suggesting a labour intensive activity. Some even expressed belief that the directory purposely lures users towards advertisements: "It's...full of ads and stuff and it takes you where you do not actually want to go." (P14-13)

In contrast, a more positive image of queries surfaces from the interviews. Users expressed this in terms of greater control: "I prefer to use my own" (P29-12); and a more direct approach: "just write it down" (P09-42). In contrast to the work metaphors used for the directory, users approached the query as a sort of messenger or servant: "I wanted to see what...those two keywords could bring me. What Web sites they could bring me" (P12-41).

This analysis is based on those who chose the query and only used queries to find responses. These issues may not be the same across our entire set of 48 participants, nor be consistent across all domains.

Query Formulation

Participants vary in the amount of effort they put into formulating queries. In the broader study, for example, 56% of all query terms were taken directly from the assigned topic with few additions or changes, and this figure was much higher for keyword queries as opposed to sentence queries. However, there were also participants who put quite a bit of thought into building their queries. One participant describes how she drew upon a range of considerations in formulating the query "flu shot recommendations risk Canadian".

Well, the question ... wanted categories of people who should or should not get a flu shot. So that was where the 'recommendations flu shot' came from. And the 'risk' I put in because I figured they would say something about high-risk person needing a shot. And 'Canadian' because I wanted it from Canada for some reason.... And I thought Canadian is a more common word in there. Like it will be describing, you know, maybe Canadian recommendations would be a phrase or something. (P32-11)

Like this example, most of the queries tend to be strings of words, with little or no formal structure, and syntax did not arise as a significant issue for participants when formulating queries. However, like the example above, many participants clearly put some effort into the decision of which and how many terms would be in their queries. A common approach was to build queries up from a central term or phrase, and add qualifying terms if needed. The additional terms may be used semantically, to clarify the topic, as with this query "Tylenol large doses".

Well the main category is the name of the drug, and then the second thing is the special thing about it. I'm not looking at the safety of Tylenol, I'm not looking at, if pregnant women should be using it. I'm looking at large doses, that's all I wanted to find. (P10-14)

Another reason for adding terms to a query, is to limit the scope and focus of the results,

as this participant tries to do with "Titanic history".

OK, Titanic. Well that is a really large topic. I put Titanic I'm going get all the Web pages for anything related to Titanic. I wanted to narrow it down so I tend to use 2 or 3 search words and sometimes I just get boom, I get the Web page that I want. And I wanted to see what Titanic history... could bring me. (P12-41)

It seems that many participants are aiming for queries that are neither too broad nor too specific, with the goal of retrieving a "direct hit" within the top few results, as expressed by this participant:

What keywords are going to bring me to the most, the best Web site as efficiently as possible without too much branching? So the more specific I am, if I'm too specific, nothing might come up. If I'm too broad, I'm going to get too many Web sites. (P12-41)

Participants find themselves searching for the 'magic words' that will help them reach this goal, and sometimes experience frustration that they are playing a terminological guessing game:

I found it interesting that with each sentence that I typed in, even though it had the same keywords 'tattoo history' I got very different results. I don't know why, and it doesn't make any sense, and it shouldn't happen that way, but it was because I thought it would happen that way that I tried those different sentences. (P6-44)

...it was just looking for the words and not getting my meaning at all because that's the problem, is trying to pick the right word that it can understand. (P31-42)

This ability to foresee the types and combinations of terms that are likely to appear in relevant Web sites and incorporate these into the query is a skill that Web searchers seem to acquire.

Even in seeking a balanced query, most participants tend to use relatively general queries, with few terms. This is common even when participants may have more specific concepts already in mind. Some participants use broad queries with the aim of retrieving large result sets that they can then browse through manually to find results:

I like to look at the general and then go to the specific so I've got all those sites and then, hopefully, find something with, on history. (P16-44)

More common is the approach of starting with a general query and then refining the query if necessary. One participant entered the query "I want to know about tattoos," but remembered something else:

I thought it said 'tell me more about the history of tattoos' but I might have been wrong. Maybe I just...I don't know. Yeah. Usually my first search...may have needed to be refined. I was definitely thinking about history, I just, I don't know... (P06-44)

This same participant attributed the initial query to "laziness," in not wanting to add more specific terms at the outset. However, many participants used a similar strategy when they were unsure of their query approach. Trial and error seems to be a common approach to querying, in which participants quickly enter a general 'straw dog' query, planning to make improvements if necessary:

If second hand smoking didn't work, I would probably go back or well, do another search again but with either synonyms or added words, to make a more descriptive search. (P13-12)

Not only was this experimental approach to Web searching quite common, but participants seemed to accept it very pragmatically:

Well, you're given some information so, you know, I try it. It might not work, but I try it. I was very surprised that it came up...but had it not come up, I would have tried something else. (P10-14)

Query Reformulation

The interactivity of the search process is more explicit in data on the reformulation of queries. Of all 192 tasks in the broader study, about 46% overall used a single query and a further 40% reformulated their query at least once. Two-thirds of the reformulations included two or three different queries, but one search used as many as ten different queries.

What does the interview data reveal about query reformulation? There seems to be at least three different general approaches to query reformulation. Some participants use the experimental approach noted above, in which they enter a query, scan the first page of results, and if these are not satisfactory, they go back and change the query. They go through this cycle as many times as necessary to produce a 'good' query before actually viewing any Web pages. A variation of this approach is to enter a query, and then work through the most promising results from that query by actually going and checking different Web pages. When these results have been exhausted, the participant will return, reformulate the query, and begin looking through the new results. A third approach is to break a topic into different aspects, and search each aspect by using a different query. One participant, who carefully planned his queries to search first by history, then photographs, and then the movie, used this approach for the Titanic. In this case, reformulated queries are often very different from the original query, because they are targeted at different sub-topics.

Participants clearly use the hitlist to decide whether or not a query has been effective. Few users look at the number of results, and use that as an indication of query effectiveness, as this participant noted,

If the results are few, then I'm sure that ...the keywords [are] very much correct. But if the results are too much, then my keywords are not accurate and I need to change my keywords. (P14-13)

More commonly, participants make a judgment based on the nature of the results, often noting specific terms in their queries that have skewed the results. For instance, a participant who entered "CMA" for the Canadian Medical Association, discovered that

All these acronyms are mean like, could be the Canadian Mountain Lion Association or something...yeah, California oncology. (P32-11)

Another participant entered a long question query about her mother's habit of taking sleeping pills, but found the results wanting:

It says a lot about sleeping pills, sleeping problems. But also, it's more about mom, mom's problems, so I decided to change my question. Because I was focusing on the sleeping pills, the problem of taking sleeping pills, not the problems of moms. (P20-14)

Queries that contain errors are a special case for reformulation. Overall in the broader

study about 10% of the queries contained some type of error. Analysis of this smaller sample suggests that typing errors are not the source of major problems, as users often see these mistakes themselves on the screen. However, when participants genuinely do not know how to spell key terms, it can have a major impact on the search. Several of the longest chains of reformulated queries in the larger study are the result of misspellings, despite the fact that Google prompted the participants with the correct spellings. One difficulty is that many participants did not notice the Google prompt, and another is that some of those who saw it did not believe that the suggestion was correct. A case in point is the participant who wanted material on the tennis player, Arthur Ashe, but initially spelled the name “Aurther ash” and went through six different permutations of the name until finally completing the search with the query “Arthur tennis player”. The participant disregarded the Google message, insisting, “I remember his last name is A-S-H” (P26-43). Although the main approach to handling this error was clearly trial and error, this participant also used two other common approaches to errors: learning and avoidance. The first name, Arthur, was eventually corrected after the participant saw it written somewhere in the hitlist. Learning of new terms, concepts or spellings in this way seems to play an important role in the process of Web searching and querying. Finally, by entering the query without the last name, this participant successfully worked his way around the problem. Avoiding the error by eliminating troublesome terms from queries was quite a common approach. Another participant noted that precision suffers from leaving out highly specific and hard to spell terms:

If I had put in thallium, this keyword [it] would have ...come down at least one third or one fourth, or maybe even less. (P14-31).

Having explored why people reformulate their queries, the next question is, how do participants reformulate their queries? In the larger study, there were 174 reformulated queries, and of these 20% were the same as the previous query but with one or more terms added, almost 9% were the same as the previous query but with one or more terms deleted, and close to 60% had one or more terms changed from the previous query. It seems that just as for query formulation, participants take a more experimental than strategic approach to reformulating queries. This is indicated by the query chain produced by a participant who searched for biographical information on Clinton and entered:

Initial query: the childhood of Bill Clinton;

Reformulation: the importance of Bill Clinton;

Reformulation: the life of Bill Clinton;

Reformulation: the presidency of Bill Clinton (P31-43).

Some participants also believed that the case and word order in queries would affect the results in some way, and so consciously ‘played’ with these elements in successive queries.

Conclusions

This study is both exploratory and preliminary, as the interview analysis of the full study is not yet complete. Nevertheless, the data already suggests some of the issues that are at play in Web querying in medical and research topics. For this group, the decision to use a query rather than the directory was strongly influenced by habit, and by perceptions that using queries is easier and gives the searcher more control. Term selection, rather than

syntax, was the main issue in query formulation, but participants did not seem to have clear strategies for this process. Rather, it was based on experimentation, and was significantly influenced by their perception of what resources are out there in Web space. This supports Wang, Hawk & Tenopir's (2000) suggestion that a clear understanding of the Web is critical to search success, but difficult to achieve. Finally, this study indicates the complexity of the process of iterative query construction and reformulation, and the ways in which users draw upon their own knowledge and skills, information in Web resources, search results, and system feedback to negotiate a path through the search.

Like the work of so many others, notably Belkin and colleagues (1982, 2001) and Ingwersen (1992, 1996), the data from this study strongly supports an interactive model of IR. The query filters model (see Figure 1) represents the range of factors that shape any given query. The lower three filters were very evident in this study, as participants seemed to rely heavily on mental models to guide their behaviour. However, it is not clear to what extent the participants distinguished between the system and the interface, and it is possible that the distinction between these two filters is artificial, a belief held by Belkin and colleagues (2001). This is a point that will be addressed in the fuller analysis. The top three filters were also evident in the study, although the constraints of assigned tasks made the situation and motivation filters less observable. Motivational issues may be more accurately reflected in the full data set by isolating the user-specified tasks. The knowledge filter plays a key role in the query process, but it is currently very broad. Further study could explore separately the impact of the knowledge filter elements: domain knowledge, search skills, Web experience and language skills, on the query process. Finally, the study suggests that habit and user complacency play a role in the query process, possibly acting as a brake on the constant state of flux that the interactive model suggests. This may be an element of the human cognitive space that the model does not fully reflect in its current form.

A number of implications for query interfaces can be identified. Users need support in the selection of terms for queries and the identification of correct spellings, but they do not want the system to make these choices for them. Bates' (1990) claim that users want control over their searching environment is borne out by this study. A possible approach would be to suggest queries that other users have formulated using the same or similar terms, a feature that the Alta Vista search engine has recently introduced. The role of the hitlist as the primary basis for query evaluation suggests that the search interface may need to be more integrated and less input-output oriented. A third point, is the importance of experimentation in Web querying. Search interfaces need to help users gain understanding of the Web and its content, and perhaps facilitate the natural tendency of users to experiment with different queries and tactics. For example, the search interface could run a query through a preliminary test and provide feedback to assist users in reformulating it before the actual search begins.

For the work reported here, we analyzed 24 interviews of searches completed in two domains. Our entire data set contains 192 search episodes in four domains. We are continuing to analyze that data which will add to our current knowledge base of the

search process, including a refinement of our model of query filters. This work will ultimately contribute to re-designed search interfaces that enhance the user experience.

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