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Effectiveness of Google keyword suggestion on users' relevance judgment

A mixed method approach to query expansion

Rahmatollah Fattahi, Mehri Parirokh and Mohammd Hosien Dayyani
Department of Library and Information Science, Ferdowsi University of Mashhad, Mashhad, Iran, and
Abdolrasoul Khosravi and Mojgan Zareivenovel
Department of Medical Library and Information Science, Bushehr University of Medical Science, Bushehr, Iran

Abstract

Purpose – One of the most effective ways information retrieval (IR) systems including Web search engines can improve relevance performance is to provide their users with tools for facilitating query expansion. Search engines such as Google provide users with keyword suggest tools. This paper aims to investigate users' criteria in relevance judgment regarding Google's keywords suggest tool and to see how such keywords would lead to more relevant results from the viewpoint of users.

Design/methodology/approach – Through a mixed method approach, quantitative and qualitative data were collected from 60 postgraduate students at Ferdowsi University of Mashhad, Iran, using four different instruments (questionnaire, thinking aloud technique, query logs and interviews).

Findings – Among other criteria, the "relation between suggested keywords and the information need" (with the mean rate of 3.53 of four) was considered the most important by searchers in selecting suggested keywords for query expansion. Also, the "relation between suggested Keywords and the retrieved items" (with the mean rate of 3.62) was considered the second most important criterion in judging the relevance of the retrieved results. The participants agreed that the suggested keywords by Google improved the retrieval relevance. The content analysis of the participants' aloud-thinking sessions and the interviews approved such findings.

Originality/value – This research makes a contribution to the need of designers of IR systems regarding the use of add words for query expansion. It also helps librarians how to instruct searchers with expanding their queries to retrieve more relevant results. Another contribution of the study is the identification of a number of new relevance judgment criteria for Web-based environments.

Keywords Relevance, Google search engine, Google suggest, Query expansion

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Introduction and problem statement

Information seekers may be aware of their own information needs; however, many of them are not able to express and develop their information needs formally and properly.

This is either because of their uncertainty about the words representing their needs or because of their inability to determine an appropriate information resource/tool which would best fulfil their needs. Kuhlthau (1991) conceived uncertainty which an information searcher has before and somewhat during the searching process as a major factor influencing their information seeking behaviour. She regards this uncertainty as a primary motivator and important principle in the information seeking process. When encountering some special situations and being unable to correctly understand an information problem, an information searcher tends to be uncertain and begins to search the needed information to reduce his/her uncertainty. This kind of uncertainty accompanies the searcher until the end of the searching process when some certainty is attained. For reducing uncertainty, users of information retrieval (IR) systems, including search engines, need intelligent tools to assist them throughout the searching process.

Many intelligent search engines have developed their search features to fulfil users' information needs. Despite the relative success of these features, many users are not satisfied with retrieval results in response to their real information needs (Casasola and Gauch, 1997; Chowdhury and Soboroff, 2002; Pokorny, 2004). These problems appear to be due to several issues including, among others, the formulation of search statements (Baeza-Yates *et al.*, 2004; Chowdhury, 1999; Lawrence and Giles, 1998; Schatz *et al.*, 1996), browsing retrieved items (Spink *et al.*, 1998), different searching algorithms (Ellis *et al.*, 1998; Spink *et al.*, 1998), different approaches users take in applying the same search queries (Sugiyama *et al.*, 2004; Wang and Davison, 2008), various ways for reformulating the search statement and incorrect query expansion (Fattahi *et al.*, 2008; Jansen and Rieh, 2010, Spink *et al.*, 2002; Widyantoro and Yen, 2001).

Although a number of years have passed since search engines were first developed, users still experience some problems. These problems can be solved relatively easily by applying facilities introduced by intelligent software based on the user's knowledge background (Ferreira and Atkinson, 2007). Taking into account the different problems users encounter during their searching process – especially when using search engines – an appropriate approach to query expansion is to provide them with suggested keywords which previous users have entered into the search box. It is worth noting that the development of such a facility needs further research. In addition, regarding the main goal of IR systems – that is, to retrieve relevant information – users' relevance judgment regarding the selection of keywords suggested by search engines, and also the effectiveness of such keywords in retrieving relevant information, are of great significance to studies about IR systems.

Although suggesting keywords which previous users have used in their information search process is an approach that the Google search engine uses for query expansion, some issues are not yet clear in this context: to what extent do these suggested keywords fulfil the users' relevance criteria? Using the suggested keywords, how relevant do searchers perceive the retrieval results are to their needs? The findings of this study would be helpful in developing better tools for query expansion based on suggested keywords.

Query expansion defined

Various definitions have been made of query expansion. Efthimiadis (2000) defined it as the process of adding or deleting some terms or phrases to/from primary query

statements automatically or semi-automatically. Fattahi *et al.* (2008) defined it as the process of refining a query statement for retrieving more relevant documents. Such expansion is done by adding some new terms or removing other terms to the primary query to reduce irrelevant or less relevant items (Efthimiadis, 2000). This helps users clearly define their information needs. The query expansion process is made in such a way that it improves the search statement which results in relevance enhancement in the retrieved information so that the retrieved items have the user's features and criteria, including the complexity of content, knowledge-base of the user, subject depth and information type or approach (Efthimiadis, 2000; Fu *et al.*, 2005).

Query expansion is regarded as a new feature in a number of search engines. When a user starts entering his/her keyword in the search box, the search engine guesses what terms or phrases the user intends to search. Then, it suggests some related keywords based on the similarity of the query words with what previous users used for searching. Early research showed that factors, such as correct spelling of entered terms, correct structure of the queries representing the information need, different aspects of the same concept and the different meaning backgrounds and contexts for the same term/phrase, affect the selection of a certain suggested term by users for query expansion. Common algorithms search engines apply for extracting suggested keywords and phrases include the process of identifying and listing the keywords and phrases the previous users applied for satisfying their information needs in search engines (Andreou, 2005; Jeon *et al.*, 2005; Wen *et al.*, 2002).

Literature review

Many studies have been conducted on relevance judgment in online search environments during recent years (Savolainen and Kari, 2005). However, there is little research on the relevance of suggested keywords provided by search engines.

Two pioneering studies that provided the main relevance criteria for many subsequent experimental studies on the topic were carried out by Barry and Schamber (1998). Earlier, Schamber (1991) studied the relevance criteria regarded by 30 expert users in meteorology in their real information search/retrieval situations. Interviewing the users resulted in 118 criteria for evaluating information resources which were categorized into ten broad categories. In line with this, Barry (1994) used criteria identified by users for evaluating the information items retrieved in response to users' information needs. Through a content analysis of 989 responses, 23 categories of relevance criteria related to document content were identified including, among others, the subject field, depth, novelty, precision and credibility of the topic.

Ahn (2003) studied the relevance criteria and factors affecting users' relevance judgments during surfing and tracing Web links and found that "the title of a link" is the most important Web page element for tracing it, and "the subject" is the main element for the information seeking process. Studying the criteria users apply for evaluating Web pages when searching information for a special field, Tombros *et al.* (2005) found that "the content of a web document" is the most important element for deciding the usefulness of Web documents. "Structure" and "quality" were the other two priorities. Studying the changes in relevance judgment criteria and in the information seeking process, Taylor *et al.* (2009) pointed out that

"understandability", "clarity", "depth or scope" and "narrowness" of the topic at hand are important relevance criteria for retrieved documents in the information seeking process. Chu (2010) noted that "subject relevance" and "subject narrowness" are of users' main relevance judgment criteria. In her doctoral dissertation, Abam (2010) showed that "subject correspondence", "credibility", "accuracy", "understandability" and "up-to-dateness" of the topic at hand are the main elements users consider in judging the relevance of information provided in Web pages. Chen and Xu (2005), Hirsh (1999), Maglaughlin and Sonnenwald (2002) and Tang and Solomon (1998) have all studied relevance judgment in different contexts.

In summary, researchers for most of the studies used survey methods. In many cases, the research instruments also included questionnaire, think aloud technique and data capturing in online environments (e.g. the River Past software). The overall finding in the literature is that traditional criteria are not sufficient for investigating the relevance of information; however, there are other subjective and contextual factors involved in relevance judgment. In addition, relevance judgment is heavily dependent on the user's understanding, goals, knowledge-base and personal characteristics, and is influenced by other factors, such as the search topic.

Research questions and hypothesis

In this study, two questions and one hypothesis were set forth as follows:

RQ1. What factors influence the searchers' selection of Google's suggested keywords for query expansion?

RQ2. What factors influence the searchers' relevance judgment regarding the retrieved documents in response to query expansion?

H1. From the viewpoints of the searchers, there is a significant difference between the extent of the relevance of documents retrieved before and after query expansion based on Google's suggested keywords.

Research methodology

Using a mixed (qualitative-quantitative) method, this research collected data through four different tools. The participants' information search processes and their aloud-thinking sessions were recorded and analysed. A relevance criteria checklist was used with a five-scale Likert-type two-sectioned questionnaire for identifying the criteria participants applied for the selection of Google's suggested keywords and for assessing the relevance of the retrieved items. The checklist was adopted from a number of related studies on relevance criteria, including those by Barry (1994), Barry and Schamber (1998), Choi and Rasmussen (2002), Chu (2010), Hirsh (1999) and Taylor (2008).

At first, participants were asked to select a topic of interest and conduct a search in Google, and then repeat the same search (i.e. doing query expansion) by using Google's suggested keywords. After these two phases, they were asked to talk about the reasons for the selection of suggested keywords they used for query expansion and their reason for the relevance of information they retrieved. Finally, they completed the related section of the questionnaire after the completion of each phase.

The research sample included 60 graduate students (MA and PhD) majoring in humanities and non-humanities fields at Ferdowsi University of Mashhad, Iran.

Regarding the mixed method approach of the study, a group of 30 students (as a minimum acceptable sample size) was assigned for each of the two fields, and a separate search session was held with each participant. The search process of each participant was recorded in transaction log files. It is clear that selecting 60 participants who are familiar with searching through the Google search engine and the ways to conduct query expansion needs purposive sampling rather than random selection.

Findings

In this section, the quantitative and qualitative data and related findings are provided under each research question/hypothesis:

RQ1. What factors influence the searchers' selection of Google's suggested keywords for query expansion?

Quantitative findings

When searching Google and using its suggested keywords for query expansion, users tend to judge the relevance and appropriateness of such keywords. Data on the relevance judgment of suggested keywords and that of retrieved items resulting from applying these keywords were collected by a two-sectioned questionnaire. The first section included 13 questions which measured users' relevance judgments about the selection of Google's suggested keywords. Table I shows the means and standard deviations (SDs) of users' responses to these questions.

As Table I indicates, among the relevance criteria participants considered for the suggested keywords, "corresponding to information need" (with a mean rate of 3.53) and "sufficient number of suggested keywords" (with a mean rate of 2.88) had the highest and the lowest ranks, respectively. The former criterion with a mean of 3.53 in comparison with the expected maximum mean of 4 had the highest rank probably because of its importance to the searchers in their initial step of searching. When entering their own keywords in the search box, users expect that they would observe some suggested terms which correspond to those they initially entered. In other words, a user focuses on a suggested term when it corresponds with his/her own terms and traces other relevance criteria after achieving this main factor. One probable reason for

Table I. Means ± SD of users' responses to questions related to their relevance judgments on Google's suggested keywords and phrases

No.	Item	Mean	SD
1	Corresponding to the information need	3.53	0.70
2	Showing different subject aspect	3.37	0.74
3	Facilitating query formulation	3.37	0.74
4	Informing properties	3.33	0.70
5	Time saving	3.30	0.91
6	Helping to solve foreign language problems	3.22	0.86
7	Determining search depth and scope	3.15	0.84
8	Introducing new issues and debates	3.12	0.86
9	Helping in formulating search statements	3.12	0.86
10	Helping in identifying various aspects of the subject	3.08	0.79
11	Helping to understand the subject	3.05	0.93
12	Novelty	2.93	0.90
13	Sufficient quantity	2.88	0.88

the lowest rank of "sufficient number of suggested keywords" is the lack of awareness about the necessity of the number of limited suggested keywords as well as the limitation of human working memory. Some researchers, such as Anick (2003) showed that, due to the limitation of human working memory, it is better that the number of suggested terms be fewer than ten.

Qualitative findings

The content analysis of recorded files of the think aloud comments by users about the relevance criteria they consider when evaluating Google's suggested that keywords revealed that the participants regarded the criteria, such as demonstrating the special aspect of the subject, differently categorizing the subject, showing the main subject and its subdivisions and limiting the subject to a special field, as important ones in judging the relevance of the suggested keywords. For instance, user number 1 selected "inflation" as his search term for searching through Google. In addition to the first suggested term ("inflation") which correctly corresponded to this participant's actual information need, he identified the phrases "inflation calculator", "inflation rate" and "inflation risk" as relevant keywords for his information need because of their capacity for demonstrating some special aspects of the need. Among the suggested keywords, five keywords indicated the historical period ("inflation rate 2010", "inflation in 2011" and "inflation 2010"), two showed general aspects ("inflation index" and "inflation definition") and one showed its geographical aspect ("inflation USA").

Analysing the contents of the think aloud records revealed interesting results. An approach similar to the approach Google applies for suggesting keywords has long been used in cataloguing as "subject headings" which are assigned to books being catalogued. The experience of using such tools by participants in different libraries appears to contribute to their initial selection of the search keyword. An overview of the 60 primary selected keywords by the participants showed that they are relatively similar to the structure of headings and subheadings in traditional vocabulary control tools such as the Library of Congress List of Subject Headings:

RQ2. What factors influence the searchers' relevance judgment regarding the retrieved documents in response to query expansion?

Quantitative findings

As noted before, data on the relevance judgment of suggested keywords and phrases and those of retrieved items resulting from applying these terms and phrases were collected by a two-sectioned questionnaire. The second section included 19 items that measured the users' relevance judgments of retrieved documents in response to Google's suggested keywords. Table II shows the means and SDs of users' responses to these questions.

As Table II shows, "corresponding to suggested keywords and phrases" (with a mean rate of 3.62) and "validity of results" retrieved in the search session (with a mean rate of 3.53) had the highest ranks as to participants' relevance judgment on retrieved documents. "Enjoyment" of retrieved documents (with a mean rate of 2.80) and that of "attractiveness" (with a mean rate of 2.90) had the lowest ranks as to participants' relevance judgment on retrieved documents.

No.	Item	Mean	SD
1	Correspondence to suggested terms	3.63	0.71
2	Validity of results	3.53	0.83
3	Having scientific approach	3.50	0.87
4	Easy access to relevant resources	3.48	0.65
5	Professional level of retrieved items	3.47	0.75
6	Resource novelty	3.45	0.81
7	Web site's credit	3.45	1.00
8	Understandability	3.43	0.83
9	Least effort	3.42	0.67
10	Author(s)' authority	3.32	1.7
11	Prioritizing retrieved items	3.30	0.98
12	Recall	3.25	0.84
13	Sufficient quantity	3.23	0.77
14	Descriptive-analytic approach	3.07	0.94
15	Having new approach to retrieving results	3.05	1.06
16	Describing details	3.03	1.04
17	Confirming previous beliefs and knowledge	2.53	1.25
18	Attractiveness of keywords and phrases suggestion technique	2.90	0.95
19	Enjoyment	2.80	1.02

Table II.
Means ± SD of users' responses to items related to their relevance judgments on retrieved items

It is worth noting that 16 items (of 19) had mean rates higher than 3 (the point that falls in "important" ranges of Likert-type scales). This shows that users value many other criteria as important in judging the relevance of retrieved documents.

Qualitative findings

Content analysis was carried out based on the recorded files of the think aloud sessions regarding the retrieved documents in response to using Google's suggested keywords. The criteria that the participants identified in their judgment about the relevance of retrieved items were extracted and codified as a phrase. Then, each codified phrase was matched with the criteria included in the questionnaire. Overall, 1,692 frequencies of criteria (including repeated ones) were identified by the participants based on 600 retrieved items. After the comparison of these criteria with those in the questionnaire, 12 new criteria were identified and categorized into four categories. Table III summarizes the data of the aloud-thinking approach.

Of the 1,692 relevance judgments made on retrieved items, 102 cases referred to the "links" category including three relevance criteria. The criterion of "internal links to the same document" indicates that the document has some links to the main items and citations within the same document which facilitate its review. The criterion of "internal links to the same web site" refers to links to other related pages and resources within the same Web site. The criterion of "external links to other related documents and web sites" facilitates browsing other related external documents, pages and resources beyond a certain document or Web site. One participant said, "With external related links, I will be able to access more resources and, by finding a document, I will be able to retrieve others". The participants' focus on tracing different links corresponding to their search topic was also revealed by observing their search sessions and analysing the transaction files.

No.	New category	Criterion (reason for accepting retrieved results)	Frequency	(%)
1	Links	Using internal links to the same document	36	14.2
		Using internal links to other items and resources within the same web site	31	12.2
		Using external links to other related documents and Web sites	35	13.8
2	Presentation formats	PDF	94	37.0
		PPT, HTML, DOC	14	5.5
		Multimedia (film, sound, image and/or video)	6	2.4
3	Document types	Scientific paper and/or book	17	6.7
		Web page with statistical information	4	1.6
		Retrieved item with the title similar to the subject	6	2.4
4	Web indicators	Using citation indicators (prioritizing based on highly cited indicator)	4	1.6
		Using webometric indicators for rankings	4	1.6
		Using other ranking indicators	3	1.2
	Total		254	100

Table III. New relevance categories and criteria identified by analysing the participants' aloud-thinking records

Of 1,692 cases, 114 relevance judgments were related to "presentation formats" and included three relevance criteria. A PDF of a document accompanying other subject-related relevance criteria was highly valued with the frequency of 94. One participant pointed out that, "most of scientific papers are in PDF format and often relate to the topic". In addition, other formats, from PowerPoint to video files, have been appreciated.

"Document types" included three criteria and had a frequency of 27. Participants welcomed retrieved books and articles. Some aspects of the retrieved items, especially the statistical aspect, were considered important. This implies the need for statistical information in academic studies in which the participants were involved. In addition, the relevance of the title of the retrieved document to the search topic was another criterion. The researchers' observations confirmed this claim.

Another relevance category consisting of three criteria was the category of "web indicators". It had a frequency of 11 among the new criteria. Some Web sites, such as Google Scholar which ranks retrieved items based on their citations, were highly considered as relevant by the participants. They also regarded other documents relevant which are ranked according to webometric indicators and other ranking methods:

H1. From the viewpoints of the searchers, there is a significant difference between the relevance of documents retrieved in response to the primary search and the relevance of documents resulting from Google's suggested keywords (query expansion).

To test the hypothesis, user judgments were compared on the relevance of the retrieved documents resulting from their primary search term/phrase with the relevance of documents retrieved in response to query expansion through Google's suggested keywords. As the distribution of required data was not significantly normal ($z -3.220$, sig 0.001), the Wilcoxon non-parametric test was used. The means of the participants'

judgments on the relevance of both groups of retrieved documents were compared. As shown in Table IV, there was a significant difference between the participants' relevance judgments. This means that the suggested keywords and phrases were effective in improving the relevance of the information retrieved. Such a result is important because of its potential to further studies on relevance judgment and indirectly indicates that the acceptance or rejection of an information item may result from some factors relating to an individual user, such as his/her special information needs, situational contexts and decision-making trends.

Discussions and concluding remarks

Query expansion is an approach by which search engines tend to assist their users in formulating their queries and to improve retrieval relevance. As retrieving relevant items is the optimal goal of any IR system, IR systems attempt to focus highly on relevance-related issues and relevance judgment.

Figure 1 shows the information-seeking process together with relevance judgment. A user starts searching through a certain search engine primarily based on his/her subject knowledge-base and individual experiences. The search engine suggests some keywords and phrases for probable query expansion. According to certain criteria, the user judges the relevance of these suggested keywords with his/her information need. If the suggested term(s) match with the need, then he/she selects it for repeating the search. Otherwise, the user reformulates another query. After reformulating the appropriate query and retrieving some items, he/she judges the relevance of the retrieved items based on certain relevance criteria. If the retrieved item(s) corresponded to the user's information need, he/she uses them. Otherwise, the user reformulates the previous query in hope of retrieving relevant items. He/she repeats the process until some relevant items, according to his/her relevance criteria, are retrieved.

IR systems should consider these criteria for developing effective retrieval interfaces in which suggesting appropriate keywords for query expansion is emphasized. As the results showed, in the evaluation of items retrieved, users mostly consider the relevance criterion "the corresponding information retrieved to the information need the most important criterion". This confirms Borland's (2003) viewpoint on user topic/subject relevance as a basic necessity. In addition, other criteria also are taken into consideration in relevance judgment. Situational relevance is another higher level criterion. In summary, users pay attention to various relevance criteria, especially those relating to the quality of retrieved items. Our findings are also in line with the findings by Chu (2010), Savolainen and Kari (2005) and Taylor *et al.* (2009), who found that "corresponding to the topic in hand" and "demonstration of the special aspects of the subject" are of the most important relevance judgment criteria that information users focus on when evaluating the information retrieved.

Table IV.
Wilcoxon test for investigating the difference between participant judgments on the relevance of retrieved items achieved by using primary and secondary search terms

No.	Statistic	Value	Mean	
1	Wilcoxon	−3.746	Search expansion	23.7
2	Sig	0.001	Primary search	20.6

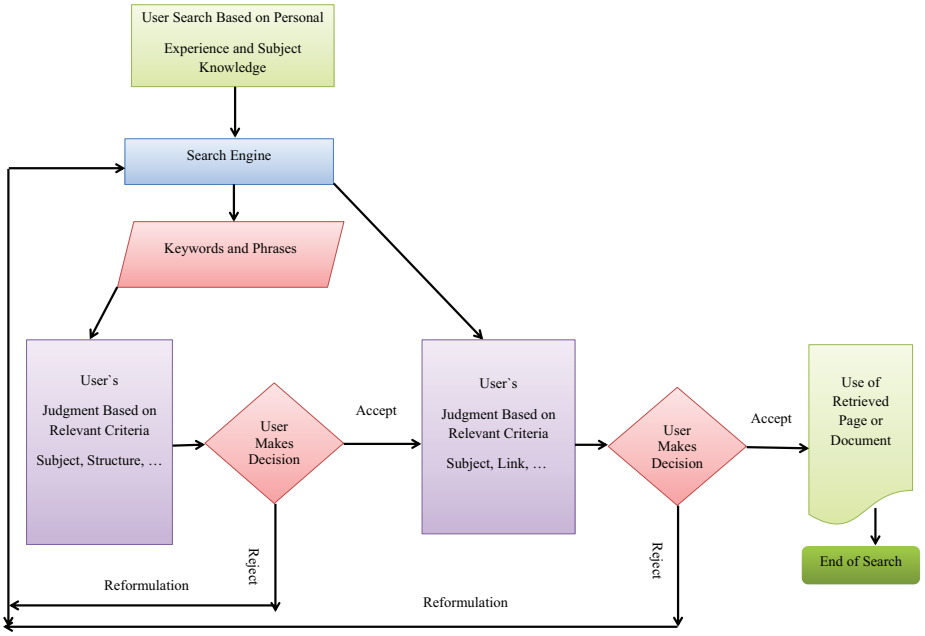

Figure 1.
Proposed conceptual model of the information seeking process and the role relevance judgment

Although the findings showed that the use of suggested keywords by users for query expansion leads in retrieving more relevant items, these keywords should be designed and developed in such a way that result in user satisfaction and ease of retrieval and help users navigate the Web environment more effectively. However, the confirmation of our findings needs further research. The improvement of the notion of suggested keywords in search engine results in a more user-friendly environment and a more effective searching interface, which in turn would enhance the information-seeking process. The identification of different relevance criteria is of importance and needs further research. More research is needed to increase our knowledge about the concept of relevance as a complex human-related issue.

References

Abam, Z. (2010), "The study of users' browsing behavior and relevance judgment in web-based meta-link environment", PhD Dissertation, Library and Information Science, Ferdowsi University of Mashhsad, Mashhsad

Ahn, M. (2003), "Exploring factors affecting users' link-following decision and evaluation behavior during web browsing", PhD Thesis, School of Information Studies, University of Pittsburgh, Pittsburgh, PA.

Andreou, A. (2005), "Ontologies and query expansion", Master's thesis, School of Informatics, University of Edinburgh, Edinburgh.

Anick, P. (2003), "Using terminological feedback for web search refinement: a log-based study", *Proceedings of the 26th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, ACM, Bethesda, MD*, pp. 88-95.

Baeza-Yates, R., Hurtado, C.A. and Mendoza, M. (2004), "Query recommendation using query logs in search engines", in Lindner, W., Mesiti, M., Türker, C., Tzitzikas, Y. and Vakali, A. (Eds), *EDBT Workshops*, Springer, New York, NY, pp. 588-596.

Barry, C.L. (1994), "User-defined relevance criteria: an exploratory study", *Journal of the American Society for Information Science*, Vol. 45 No. 3, pp. 149-159.

Barry, C.L. and Schamber, L. (1998), "User's criteria for relevance evaluation: a cross-situational comparison", *Information Processing and Management*, Vol. 34 Nos 2/3, pp. 219-236.

Borland, P. (2003), "The concept of relevance", *Journal of the American Society for Information Science & Technology*, Vol. 54 No. 10, pp. 913-925.

Casasola, E. and Gauch, S. (1997), "Intelligent Information Agents for the World Wide Web", Technical Report ITTC-FY97-11100-1, Information and Telecommunication Technology Center, University of Kansas, Lawrence, KS.

Chen, Z. and Xu, Y. (2005), "User-oriented relevance judgment: a conceptual model", paper presented at Proceedings of the 38th Hawaii International Conference on System Sciences, Hawaii, HI.

Choi, Y. and Rasmussen, E.M. (2002), "User's relevance criteria in image retrieval in American history", *Information Processing and Management*, Vol. 38 No. 50, pp. 695-726.

Chowdhury, A. and Soboroff, I. (2002), "Automatic evaluation of World Wide Web search services", *Proceedings of the 25th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, ACM, Bethesda, MD*, pp. 421-422.

Chowdhury, G. (1999), "The Internet and information retrieval research: a brief review", *Journal of Documentation*, Vol. 55 No. 2, pp. 209-225.

Chu, H. (2010), "Factor affecting relevance judgment: a report from TREC legal track", *Journal of Documentation*, Vol. 67 No. 2, pp. 264-278.

Efthimiadis, E.N. (2000), "Interactive query expansion: a user-based evaluation in a relevance feedback environment", *Journal of the American Society for Information Science*, Vol. 51 No. 11, pp. 989-1003.

Ellis, D., Ford, N. and Furner, J. (1998), "In search of the unknown user: indexing and hypertext and the world wide web", *Journal of Documentation*, Vol. 54 No. 1, pp. 28-47.

Fattahi, R., Wilson, C.S. and Cole, F. (2008), "An alternative approach to natural language query expansion in search engines: text analysis of non-topical terms in web documents", *Information Processing and Management*, Vol. 44 No. 4, pp. 1503-1516.

Ferreira, A. and Atkinson, J. (2007), "Intelligent search engines", McGraw-Hill supplemental articles, available at: http://books.mcgraw-hill.com/EST10/site/supparticles/Intelligent-search-engines-YB070360.pdf (accessed November 2014).

Fu, G., Jones, C.B. and Abdelmoty, A.I. (2005), "Ontology-based spatial query expansion in information retrieval", *On the Move to Meaningful Internet Systems 2005: CoopIS, DOA, and ODBASE (Vol. 3761 of the series Lecture Notes in Computer Science)*, Springer, Berlin Heidelberg, pp. 1466-1482.

Hirsh, S.G. (1999), "Children.N's relevance criteria and information seeking on electronic resources", *Journal of the American Society for Information Science*, Vol. 50 No. 14, pp. 1265-1283.

Jansen, B.J. and Rieh, S.Y. (2010), "The seventeen theoretical constructs of information searching and information retrieval", *Journal of the American Society for Information Science and Technology*, Vol. 61 No. 8, pp. 1517-1534.

Jeon, J., Croft, W.B. and Lee, J.H. (2005), "Finding semantically similar questions based on their answers", *Proceedings of the 28th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, ACM, Bethesda, MD*, pp. 617-618.

Kuhlthau, C. (1991), "Inside the information search process: information seeking from the user's perspective", *Journal of the American Society for Information Science*, Vol. 42 No. 5, pp. 361-371.

Lawrence, S. and Giles, C.L. (1998), "Context and page analysis for improved web search", *IEEE Internet Computing*, Vol. 2 No. 4, pp. 38-46.

Maglaughlin, K.L. and Sonnenwald, D.H. (2002), "User perspectives on relevance criteria: a comparison among relevant, partially relevant, and not-relevant judgments", *Journal of the American Society for Information Science and Technology*, Vol. 53 No. 5, pp. 327-342.

Pokorny, J. (2004), "Web searching and information retrieval", *IEEE Computer Software*, Vol. 6 No. 4, pp. 43-48.

Savolainen, R. and Kari, J. (2005), "User-defined relevance criteria in web searching", *Journal of Documentation*, Vol. 62 No. 6, pp. 685-707.

Schamber, L. (1991), "Users' criteria for evaluation in multimedia information seeking and use situations", Unpublished Doctoral Dissertation, Syracuse University, Syracuse, New York, NY.

Schatz, B.R., Johnson, E.H., Cochrane, P.A. and Chen, H. (1996), "Interactive term suggestion for users of digital libraries: using subject thesauri and co-occurrence lists for information retrieval", *Proceedings of the First ACM International Conference on Digital Libraries, ACM, Bethesda, MD*, pp. 126-133.

Spink, A., Greisdorf, H. and Bateman, J. (1998), "From highly relevant to not relevant: examining different regions of relevance", *Information Processing and Management*, Vol. 34 No. 5, pp. 599-621.

Spink, A., Ozmutlu, H.C. and Ozmutlu, S. (2002), "Multitasking information seeking and searching processes", *Journal of the American Society for Information Science and Technology*, Vol. 53 No. 8, pp. 639-652.

Sugiyama, K., Hatano, K. and Yoshikawa, M. (2004), "Adaptive web search based on user profile constructed without any effort from user", *Proceedings of WWW 2004, New York, NY, 17-22 May*, pp. 675-684.

Tang, R. and Solomon, P. (1998), "Towards an understanding of the dynamics of relevance judgments: an analysis of one person's search behaviour", *Information Processing & Management*, Vol. 34 Nos 2/3, pp. 237-256.

Taylor, A. (2008), "Examination of relevance criteria choices and the information search process", *Journal of Documentation*, Vol. 65 No. 5, pp. 719-744.

Taylor, A., Zhang, X. and Amadio, W.J. (2009), "Examination of relevance criteria choices and the information search process", *Journal of Documentation*, Vol. 65 No. 5, pp. 719-744.

Tombros, A., Ruthven, I. and Jose, J.M. (2005), "How users assess web pages for information seeking", *Journal of the American Society for Information Science and Technology*, Vol. 56 No. 4, pp. 327-344.

Wang, J. and Davison, B.D. (2008), "Explorations in tag suggestion and query expansion", *Proceeding of the 2008 ACM Workshop on Search in Social Media (SSM '08), ACM, New York, NY*, pp. 43-50.

Wen, J.R., Nie, J.Y. and Zhang, H.J. (2002), "Query clustering using user logs", *ACM Transactions on Information Systems*, Vol. 20 No. 1, pp. 59-81.

Widyantoro, D.H. and Yen, J. (2001), "A fuzzy ontology-based abstract search engine and its user studies", *The 10th IEEE International Conference on Fuzzy Systems*, IEEE, Piscataway, NJ, Vol. 3, pp. 1291-1294.

Further Reading

Schamber, L. and Bateman, J. (1996), "User criteria in relevance evaluation: toward development of measurement scale", *Proceedings of the ASIS Annual Meeting*, Vol. 33 No. 1, pp. 218-225.

Saracevic, T. (2006), "Relevance: a review of the literature and framework for thinking on the notion in information science. Part II: nature and manifestations of relevance", *Advances in Librarianship*, Vol. 30 No. 1, pp. 3-69, available at: www.scils.rutgers.edu/~tefko/Advances_librar_2006.pdf (accessed 13 November 2014).

Corresponding author

Abdorasoul Khosravi can be contacted at: khosravi2422@gmail.com