

Revisiting informativeness as a process measure for information interaction

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ABSTRACT

The intent of this paper is to re-introduce and discuss the applicability of the *informativeness* concept to web-based information seeking and retrieval environments. Informativeness is rare among IR evaluation concepts, in that it focuses on the value of the process of interaction with a set of documents, rather than on the success of the algorithm matching documents to information needs. It is notable as an early attempt to bridge traditional system evaluation with the new-at-that-time perspective on the role of the user in the evaluation of the system.

Keywords

informativeness, search trails, search process

1. INTRODUCTION

the evaluation of information retrieval systems should be based on measures of the information provided by the retrieval process, 'informativeness' measures which take into account the interactive and full-text nature of present-day systems and the different types of questions which are asked of them. [1]

Web-based information seeking and retrieval (IS&R) can be described as a process of interaction between people and diverse sets of digital objects, information, technologies and applications, with the primary goal of becoming informed about something. User-centred approaches have characterized the motivation for IS&R as a gap in or lack of knowledge, and have emphasized the cognitive processes associated with bridging this gap through making sense, learning and becoming informed [2, 3]. This conceptual framework is based on what Buckland [4] refers to as "information-as-process", because it emphasizes the change that takes place in the searcher through interaction with information objects.

Given that search engines are the main tools used to support IS&R activities on the Internet, it might be reasonable to think that they would provide support for the process of becoming informed. However, most search engines take a rather limited, transaction-based approach to web searching based on the "information-as-thing" approach [4]. To extend the knowledge gap metaphor, search engines are well-designed to retrieve sets of information objects that may fill the gap, but are not very well-designed to support people as they interact with the information and build bridges to span the gap. At the interface level, this limited approach to search system design has been exacerbated by the general perception that Google's "less is more" approach is optimal.

However, the lack of attention paid to the information interaction process is rooted more fundamentally in some of the key theoretical assumptions of the IR field. First among these, is that IR is primarily concerned with the relevance relationship between documents and user needs, rather than on learning, task completion or other broader process outcomes. Second, is that the goal of IR system design is to retrieve all the relevant documents and as few of the non-relevant as possible [5]. By focusing on balancing recall and precision, search systems do not provide good solutions for many searchers, who are simply seeking the shortest path to some level of information saturation. The third, expressed in the probability ranking principle, is that the best possible rank order of results is in decreasing probability of their relevance to the user. As noted by van Rijsbergen [5], this is highly problematic, as it assumes that the relevance of a document is independent of the other retrieved documents. In fact, we know that documents in a set may contain redundant or complementary information, and that the order in which the documents are viewed can have a major impact on relevance judgments [6, 7].

While it is true that search engine users have become accustomed to sifting through long lists of disconnected results, the act of filtering, sorting and making sense of them still constitutes a major cognitive challenge. It is unlikely that systems will start to address this challenge until IR evaluation frameworks are able to incorporate users and their goals in a meaningful way. Some notable work has been done in this area, focusing on using more realistic evaluation tasks, accommodating graded relevance assessments, and developing new and more realistic evaluation metrics [8-10]. Work at the TREC conferences has also begun to consider more user interaction issues, for example through the Web, HARD, and Novelty tracks, however much of the evaluation work in these tracks continues to be devoid of user participation.

2. DEFINING INFORMATIVENESS

The intent of this paper is to re-introduce and discuss the applicability of the *informativeness* concept to web-based IS&R environments. Informativeness is a user-centred concept for evaluating the effectiveness of a retrieval process, which was first proposed by Tague [11] 20 years ago. She updated it some years later in response to the move from traditional text retrieval systems to full-text interactive systems, "in which the searcher follows trails in online or ondisk databases, rather than scanning batches of 'hits'" [1]. Tague and her students developed and tested the measure, but plans to validate it in a larger study were not realized after Tague passed away in the midst of the project in 1996.

The concept of informativeness is based on a user-centred, subjective understanding of information. Tague [11] cites Fox's definition: "the information carried by a set of sentences ...is the conglomerate proposition expressed by the sentences, a proposition which the originator of the sentences is in a position to know to be true....[and] which the recipient can read and understand"[12]. Thus, the informativeness value of an information object or set of objects is determined by "the amount of information which it carries or conveys to an individual....in the context of a particular query or information need." [11]

Tague's primary focus in developing the informativeness measure was to assess the value of interactive search processes and the impact of the order in which a set of retrieved information objects are encountered. Tague explains that at the process level, "Informativeness is ... related to the completeness and ordering of the search trail with respect to some expected or ideal answer set. The information provided by a text is context sensitive, in that it depends on what has already been read, on the reading order.[1]"

In considering how the informativeness of a search trail is affected by the order of display, Tague identified three types of document dependencies.

Independence: an object is independent of other objects in the set if it deals with an aspect of the information need not covered elsewhere.

Complementarity: an object is complementary if its informativeness is influenced or influences other objects in the set. In this case, the order in which objects are displayed may add or detract from the overall informativeness.

Referential (redundancy): an object is in a referential relationship with other objects in the set, if it contributes no new information and does not increase the informativeness of the search trail.

Informativeness is clearly related to the intertwined concepts of cognitive and situational relevance [13], as it depends on the extent to which information objects, both individually and in the aggregate, suit a users' cognitive and practical needs with respect to the task of becoming informed. However, the concept of informativeness is more pragmatic than relevance. Relevance claims that an information object is related or suited to the information need in some manner, which implies potential usefulness. Informativeness, on the other hand, claims that a searcher has actually interacted with an information object or collection of objects and has become informed to some extent. Thus, while relevance is well-suited to the evaluation of document surrogates, which are used to predict the usefulness of the actual documents, informativeness has more to offer as a measure of information interaction in full-text environments, in which the searcher reads and becomes informed as part of the search process.

Informativeness is also related to the concept of novelty, which is the main user-centered caveat to the probability ranking principle. Novelty has been studied to some extent by the IR research community, primarily in terms of novelty detection [14]. However, novelty is only one aspect of informativeness, since the outcome of a process of information interaction may be affected by the many different ways in which information objects are related to one another and to the searcher, such as explanation, elaboration, confirmation, etc.

Both at the level of individual information objects and at the aggregate level of an ordered set of results, informativeness is a subjective concept; a function of what individual searchers can extract, understand and make use of in order to become informed. It measures the value of a user's interaction with information as guided by ranked system output, against a user-defined search path.

3. MAKING USE OF INFORMATIVENESS

Tague reasoned that given a set of search results, searchers can determine an ordinal utility function for that set. In other words, they are capable of determining a weak ordering of information objects (with some ties) based on their relative informativeness, and of determining a stopping point in the sequence. In some cases, the information need may need to be broken down into distinct, ordered aspects to facilitate this ordering [15]. This user-defined sequence represents the optimal sequence, which is then used to determine the relative informativeness value of each item in the sequence.

Based on this formalization, Tague developed an informativeness measure that scores ranked system output compared to an optimal, user-defined sequence [1]. The measure is based on a number of assumptions:

- The amount of information that an information object delivers varies from person to person, and will depend for each person on what has been previously examined.
- A user can examine the information objects retrieved and place them on a continuum based on their relative informativeness, from their own perspective.
- The informativeness of each information object is logarithmically related to the ones previously viewed, from the user's perspective.
- The overall informativeness of an ordered set of information objects is reduced when non-pertinent documents are presented or pertinent ones were presented in an order not useful to the user.

The measure combines an initial user-defined informativeness score for each object in the set with a penalty when the system does not deliver the results in the optimal order defined by users at the time of the evaluation [15].

4. MEASURING INFORMATIVENESS

Few studies have applied the informativeness measure. Tague-Sutcliffe [16] examined the search trails of 17 online catalogue searches. In this initial study to validate the metric, she found an 82% correlation between user perception of informativeness and the value of the informativeness measure.

In 1996 Toms and Tague-Sutcliffe [17] conducted two studies to apply informativeness to browsing. In the studies, ten and twenty participants, respectively, browsed and searched in digital encyclopedias. In both studies, participants performed two tasks: implicit, in which they were asked to browse anything of interest, and explicit, in which they were assigned a task with a defined goal. After each task was completed, participants did a 'free recall' of all articles on the assumption that those remembered were the most informative. Secondly, a screen capture video was replayed so that participants could identify search goals that emerged over the course of the session. Participants then matched

goals that emerged with the informative documents and ranked the documents in two ways: in the order they would have preferred to have viewed them, and in order of informativeness for the task.

Using both the trail extracted from the screen video and the informative nodes specified by the users, informativeness was calculated for each task. Initial informativeness (i.e., the information contained in the documents) by task ranged between .78 and .95. When that result was penalized by the system delay for non-optimal ordering, informativeness dropped to between .5 and .63. In the implicit task condition, participants were more likely to prefer the order in which the system presented the documents, but this was less likely in the explicit task condition.

In these studies, measures of initial informativeness suggest that the systems are performing well at the 78 to 95% precision level. However, when penalized for not displaying the documents in the optimal order, the informativeness scores of the systems drop significantly.

The most similar measure in use in laboratory IR evaluation is Cumulated Gain, which is one of a family of measures that introduce a penalty as the rank increases [18]. Like informativeness, Cumulated Gain can also accommodate graded judgments of document value. However, in addition to using document level assessment, informativeness tests the system against user-defined optimal-paths collected in situ at the time of the evaluation. This is methodologically challenging, but has the potential to increase our understanding of how to best display search results, both in general terms, and with respect to particular user groups and situations.

5. RETHINKING INFORMATIVENESS IN A WEB WORLD

The informativeness measure was developed at a time when interactive hypertext search systems were still in their infancy, yet both as a concept and as an evaluation measure, it brings some interesting perspectives to Web-based IS&R.

Objective document informativeness

At the level of individual information objects, informativeness is primarily a subjective value, in that it will be influenced by the user's need, task, preferences, etc. However, unlike relevance which is an inherently relational concept, informativeness can also be viewed as an objective feature of a document, indicative of the raw potential a document has of informing a reader. This raises the question of how the objective informativeness potential of an object may be measured.

Tague [11] suggests that it may be a function of the topic coverage and cites work by Derr [19], who proposes combining the breadth of coverage measured by the number of propositions in a text, and the depth of coverage based on the specificity of the propositions. In the web world there are any number of additional, non-textual features that may be indicative of informativeness, such as the number of links, the depth of a page in a web site, the structuredness of text, the number of images, the genre of the page, etc [20]. Recent research on entity extraction and question answering has explored statistical methods to identify the "informativeness" or discriminating power of words and sentences within texts and collections [21, 22], and these methods might also be applicable to determining a raw informativeness value for texts.

Although measuring an information object's potential for informing a user was not the focus of Tague's work, developing such a measure could be of benefit to Web-based IS&R systems. In particular, it could be used to identify informational as opposed to navigational or transactional pages, and to weight these pages for particular types of queries.

Informativeness of a search sequence

Beyond the level of individual information objects, informativeness provides insight on the ordering of search results, one of the critical issues in search engine design. As noted above, Tague's theoretical description of search trails identifies different types of dependencies between information objects [15]. Further exploration of these relationships, both theoretical and through empirical studies of user-defined search trails, could lead to a better understanding of the role of document dependencies in human information interaction.

A major challenge in predicting search trails of optimal informativeness is their variability across diverse users and information needs. Tague [1] suggests that at a general level, trails vary along two main dimensions: length (number of information objects) and consistency (degree to which optimal trails are consistent over different users), and hypothesizes that these variables are dependent upon the nature of the information need. As examples, she notes that factual search trails are likely to be very short and quite consistent among searchers, while more complex tasks are likely to have longer and more varied trails.

While individual differences will always influence preferences for the ordering of search results, it may be possible to make use of some of these contextual patterns based on tasks, information needs, domains, etc. to predict better search trails for different situations. For example, process models and genre systems used within organizational information environments could provide guidance in ordering results, by predicting the types of documents needed by searchers and the order in which they are needed. Generic models of the information seeking process [3, 23, 24] may also be of use. Given the large amounts of user behaviour data currently available in search engine logs, a fruitful approach may be to validate model-based predictions of optimal trails with data mining techniques.

Web-based IS&R involves interaction with a much more diverse range of information objects, systems and interfaces than would have been part of the search process when the informativeness measure was developed. Given the current, richer interactive environment, it is possible that the concept needs to be extended to take into account the ways in which searchers are informed by the environment as well as the objects it contains. In this way, it would be possible to consider the role that environmental cues play in enhancing the informativeness of a search process and to consider how environmental informativeness could be improved. This reconceptualization would support holistic evaluations in keeping with the way in which people experience web searching as part of a broader interaction with the web environment.

Practical Applications

Informativeness evaluation can provide design input to search engines, with the goal of providing users with support for the process of becoming informed. In practical terms, search engines need guidance on the prediction of optimal sequences of results. These could be based on general search scenarios, or customized

to different task scenarios provided by the searcher. Search engines could then provide interfaces that allow searchers to interact with these results within an application that provides support for interaction with information. Alternately, search engines could provide toolbar tour guides, to walk searchers through static or dynamically updated paths through information. A third option is to retrieve search trails, rather than individual results, so that the hitlist would contain the starting points of the highest ranked trails, optimized for different kinds of information needs or tasks. Some search engines (trexy.com, trailfire.com) have already begun to make use of the search trail concept, by allowing users to create and share their trails with others.

6. CONCLUSION

The value of reconsidering informativeness is that it has the potential to open up new ways of thinking about search systems, which extend beyond retrieval to support the broader interaction process. It forces us to think about optimizing the paths which searchers take through information in order to maximize the amount of information they can absorb and make sense of.

Informativeness is particularly valuable due to its flexibility. It can be measured both for single units of information (sentences, texts) and for search sessions involving interactions with multiple texts. Also, it can be measured as an objective textual feature, as well as a subjective measure of the interactivity between users and texts. There is considerable potential for the application of informativeness to Web-based information interaction and there are a number of open research questions of interest to the IS&R research community.

7. REFERENCES

- [1] J. Tague-Sutcliffe, "Measuring the informativeness of a retrieval process," presented at Proceedings of the 15th Annual International ACM SIGIR Conference, Copenhagen, Denmark, 1992.
- [2] B. Dervin, "On studying information seeking methodologically: the implications of connecting metatheory to method," *Information Processing & Management*, vol. 35, pp. 727-750, 1999.
- [3] C. C. Kuhlthau, "Inside the search process: information seeking from the user's perspective," *Journal of the American Society for Information Science*, vol. 42, pp. 361-371, 1991.
- [4] M. Buckland, "Information as thing," *Journal of the American Society for Information Science*, vol. 42, pp. 351-360, 1991.
- [5] C. J. van Rijsbergen, *Information retrieval*, 2nd ed. London: Butterworths, 1979.
- [6] M. B. Eisenberg and C. L. Barry, "Order effects: a study of the possible influence of presentation order on user judgements of document relevance," *Journal of the American Society for Information Science*, vol. 39, pp. 293-300, 1988.
- [7] M. A. Tiarniyu and I. Y. Ajiferuke, "A total relevance and document interaction effects model for the evaluation of information retrieval processes," *Information Processing & Management*, vol. 24, pp. 391-404, 1988.
- [8] P. Borlund, "The IIR evaluation model: a framework for evaluation of interactive information retrieval systems," *Information Research*, vol. 8, 2003.
- [9] P. Ingwersen and K. Jarvelin, *The turn: integration of information seeking and retrieval in context*, vol. 18. Berlin: Springer, 2005.
- [10] J. Kekalainen and K. Jarvelin, "Evaluating information retrieval systems under the challenges of interaction and multidimensional dynamic relevance," presented at 4th CoLIS Conference, 2002.
- [11] J. Tague, "Informativeness as an ordinal utility function for information retrieval," *SIGIR Forum*, vol. 21, pp. 10-17, 1987.
- [12] C. J. Fox, *Information and misinformation*. Westport, Conn.: Greenwood, 1983.
- [13] P. Borlund, "The concept of relevance in IR," *Journal of the American Society for Information Science*, vol. 54, pp. 913-925, 2003.
- [14] I. Soboroff, "Overview of the TREC 2004 novelty track," presented at Text Retrieval Conference, Gaithersburg, MD, 2004.
- [15] J. Tague and R. Schultz, "Some measures and procedures for evaluation of the user interface in an information retrieval system," presented at Proceedings of the 11th Annual International ACM SIGIR Conference, Grenoble, France, 1988.
- [16] J. Tague-Sutcliffe, *Measuring information: an information services perspective*. Academic Press, 1995.
- [17] E. G. Toms and J. Tague-Sutcliffe, "Informativeness as a measure of browsing effectiveness," presented at Second International Conference on Conceptions of Library and Information Science: Integration in Perspective, Copenhagen, 1996.
- [18] K. Jarvelin and J. Kekalainen, "Cumulated gain-based evaluation of IR techniques," *ACM transactions on Information Systems*, vol. 20, pp. 422-446, 2002.
- [19] R. L. Derr, "The concept of information in ordinary discourse," *Information Processing & Management*, vol. 21, pp. 489-500, 1985.
- [20] A. Tombros, I. Ruthven, and J. M. Jose, "How users assess web pages for information seeking," *Journal of the American Society for Information Science and Technology*, vol. 56, pp. 325-436, 2005.
- [21] T. Roelleke, "A frequency-based and a Poisson-based definition of the probability of being informative," presented at ACM SIGIR, Toronto, Canada, 2003.
- [22] J. D. M. Rennie and T. Jaakkola, "Using term informativeness for named entity extraction," presented at ACM SIGIR, Salvador, Brazil, 2005.
- [23] P. Vakkari, "A theory of the task-based information retrieval process: a summary and generalization of a longitudinal study," *Journal of Documentation*, vol. 57, pp. 44-60, 2001.
- [24] K. Bystrom and K. Jarvelin, "Task complexity affects information seeking and use," *Information Processing & Management*, vol. 31, pp. 191-213, 1995.