A Search Relevancy Tuning Method Using Expert Results Content Evaluation

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Abstract

The article presents an online relevancy tuning method using explicit user feedback. The author developed and tested a method of words’ weights modification based on search result evaluation by user. User decides whether the result is useful or not after inspecting the full result content. The experiment proved that the constantly accumulated words weights base leads to better search quality in a specified data domain. The author also suggested future improvements of the method.

1 Introduction

The volume of information today increases with a great speed. The classical search methods (by words match, by keywords etc) return a great amount of texts that often do not meet the user’s subjective needs. As a result, the user faces a new problem - ”search within the search results”. This conducts, first, to ineffective expenditure of time resources and, second, to decrease of user confidence in information retrieval system. Therefore, it is necessary to optimize search results taking into consideration systematized retrospective data. That is, we need to design an expert taught system capable to return search results ranked according with expert evaluation. At the same time, the user must not be obliged to make any efforts.

Today’s relevance optimization methods, widely used by search engines, such as considering number of link hits and number of hypertext links to the document in other documents (such as PageRank[3]), are appropriate only in systems of ”wide usage” (Internet) and don’t take into account peculiar properties of corporate knowledge bases. Among them are high concentration of data in certain knowledge domain and, frequently, absence of hypertext references. Moreover, the
average level of competence of corporate users is higher than the one of the "broad masses", by which the Internet is mostly presented.

In this article, the author presents theoretical and practical issues of designing and developing of an expert system that constantly optimizes search results in corporate knowledge base.

2 Earlier work

The general drawback of using traditional methods of expert evaluation is that the taught system is being explicitly trained by experts or information architects until some moment and then stops in its evolution.

One way to dispose of this problem is the usage of implicit user feedback. The most evident indication of user's interest in a document from search results is a "click". By this word, we mean any possible way of selecting the hypertext link to the document and proceeding to the document. Thorsten Joachims[4] formally justifies the use of click-through data for training and describes an unbiased approach to evaluating retrieval performance. Jared Jacobs et al[5] have recently proposed a training method using click-through data that tunes parameter weights in real time rather than offline. This makes their work a next step in solving the problem of relevance optimization. It is necessary to mention, that the search in described works was conducted over the unspecified data (Internet) that cannot be strictly referred to any knowledge domain. In these works the results evaluation depended on limited information sources: the judgment whether the document was useful was bases on its name, words in URL and a short description (which is often a few first sentences of the document).

The author assumes that in case of a narrow knowledge domain, which often corresponds with corporate databases, the earlier described methods have a substantial disadvantage. When using standard search within one or several similar knowledge domains it is much more difficult for the user to assume that the document is useful, because the judgment is based only on the document’s names and description\(^1\). Another feature of the author’s method of search results raking is the constant training of the system, since mostly all of its users may be considered as teaching experts. This partly eliminates the problem of a limited training period. The developed system gives users a relatively unconstrained option to express their personal yet competent opinion.

\(^1\)Documents in databases often do not have a readable URL since data storing methods may vary.
3 Algorithm

In the system developed by the author, the user evaluates the quality of the result after reviewing the whole document. Thus, the propriety of the evaluation increases noticeably.

3.1 Ranking

The author suggests the following algorithm of search results relevancy ranking $R(q)$:

$$f(q, d) = s \cdot N(q, d)$$  

(1)

$$R(q, d) = \sum_{i=1}^{n} c_i \cdot f_i(q_i, d)$$  

(2)

$$R(d) = \sum_{j=1}^{Q} w_j \cdot R_j(q_j, d)$$  

(3)

where $q$ is a single word from the query $Q$, $d$ is a particular document, $f$ is a function of query word-document pair, calculated as a product of $s$ (weight of a section from a section set $S$: name, content etc) and $N$ (the number of occurrences of word $q$ in document $d$). In summing by section the functions $f$ are multiplied by flag $c$, which corresponds to a user preference whether to search in the current section or not. The final value of the document relevance against the query is calculated by summing the single document relevance values against single words that are multiplied by each word’s weight $w$. The weights of sections and the initial words’ weights are the inputs to proposed algorithm.

The function $f$ may be defined in several ways. For example, we may use the query result relevance value returned by SQL-query (though one should take into consideration several peculiarities of database systems). The better version of the function may take into account the ”distance” between query words in the result document. That is, the number of words between each pair of query words. The document with less distance between words has higher relevance. For example, if the query is ”federal courts in Russia”, the document containing phrase ”federal and district courts in Russia” has higher relevance than the document containing ”federal government offices and jury courts in central Russia”.

Most of the search engines are designed on Boolean Retrieval Model. A system that adheres to this model supports the formulation of search queries by combining individual search words with the Boolean operators AND, OR, and NOT. The result array is combined of documents
through the application of corresponding AND, OR or NOT set operator. For example, the result array for a search query "data AND mining" will consist of an intersection of documents from two sets, each of which contain only one word from the query. Though being relatively effective, this model has shortcomings\[2\]. The ”if and only if” restriction leads to loss of rank order of retrieved documents, since a document either satisfies, or does not satisfy, a user’s search query. Another shortcoming is the inability of the user to specify the importance of each search term.

The author used a simplified version of function, as this question does not play fundamental role in the experiment. Different versions of function f may vary the number of query results, but does not influence the considered ranking effect.

3.2 Word weight

After reviewing the document content, the user is able to click a button as a way to evaluate the search result. After that, the weights $w$ of a set $W$ of all the query words $W^Q$ that the document contains $W^D$ are updated.

$$W = W^Q \otimes W^D \quad (4)$$

The value of weights modification depend on user’s level of competence $U$ and query result position $p$ in array of results sorted by relevancy rank $R$:

$$w' = w + \alpha \cdot U \cdot \sqrt{p} \quad (5)$$

The factor $\alpha$ is a learning rate. The user’s level of competence $U$ factor $\alpha$ is defined by experimenter.

![Figure 1: The evaluation algorithm diagram](image-url)
Consequently, the set of words with corresponding weights (weights vocabulary) is updated with every search result evaluation. Figure 1 presents the general diagram of the algorithm’s work.

It is necessary to note that the method is not applicable to a search with a single word query, since the ranking algorithm involves calculating total document’s relevancy based on sum of document’s relevancy against each query words. If the query consists of one word, all of the result documents experience the same rank alteration. This makes no change in the final results distribution.

### 3.3 Criterion

After the update of words’ weights, it is necessary to recalculate the rankings of the evaluated documents in search with identical query. Then a change $\delta$ of current result position is calculated. The judgment of each search is based on sum $\Delta$ of single position changes:

$$\delta = p' - p$$  \hspace{1cm} (6)

$$\Delta = \sum_{i=1}^{D} \delta_i$$  \hspace{1cm} (7)

where $D$ is quantity of evaluated documents.

### 4 Preparation

The author used his own program to conduct the experiment. The system developed by author is capable of structurized document storage and access rights management based on user authentication information and user groups. The user interacts with the system via web-interface.

In order to minimize the technical constraints, the system was installed on Pentium-IV-2.4GHz machine with 2GB of RAM and 160GB of disk space connected to the Internet with a 2Mb leased line.

The system in the experiment works with texts in Russian. Therefore, any following information and tables in this article should be considered as translated from Russian into English. The morphology of Russian language is more difficult, than English. For example, the current number of supported word forms for ispell open-source spellchecker in Russian is 1,24 million\(^2\), while in English it is estimated as less than 1 million. Thus the usage of Russian does not simplify the examined method.

\(^2\)Lebedev A. Russian dictionary for ispell. http://scon155.phys.msu.su/swan/orthography.html
4.1 Domain selection

For the experiment, the author used a special database "The legislation of Russia" which contained all major legislative documents of Russian Federation. The content of this base is in many respects similar to knowledge domains used in corporate knowledge bases: a substantial quantity of similar documents with professional terms. Besides, the licensed version of this database is affordable and each to find. The size of the imported base is approximately 2.3 millions of words\(^3\). The data was imported to the system manually. The source legislative database was strictly structured by independent sections of legislation. The author used the same structure.

4.2 Technological features

The system allows conducting a search across several document fields. For the experiment the author used folder (container) name, document name and document full text content. The search engine utilizes a vocabulary of stop-words from MnogoSearch search engine\(^7\). Stop-words are widely used and auxiliary lexical units that are eliminated from the query.

To the each assessor the author assigned a personal level of competence based on user's subjective estimation of professionalism in the subject. Each of the assessor was included in "training experts" user group and given read access to all the documents in system.

4.3 Data management methods

Each search query is saved in database with unique identification number. Each link in search results contains this ID as well as the resource (document) unique ID and the number of the result in result list, i.e. the position of the result in relevance ranking.

The user clicks on document link and opens the document’s page, which contains full document text and embedded dynamic page (using IFRAME HTML tag). Thus the embedded page has an evaluation submit form and all the necessary hidden identification information. Upon evaluation, all this information is submitted to the server. The server-side program updates all the words that are both in the query and in the document. The system also saves the current document position in search results list. After updating the words' weights, the program conducts an autonomous search with identical query and

\(^3\)The average length of Russian word with one white space is 6.5 characters. The "clean" size of imported texts was 15MB.
saves the difference between the document’s position before and after the evaluation for further analysis.

5 Experiment

The initial input values for section weights are set as $S$(folder, document name, document full text)=$S$(15, 10, 1). $\alpha$ and $w$ for all words are set equal to 1, as well as all users’ competence level $U=1$.

The relevance judgment logic is binary - whether the document is relevant to the search query of not. To define relevance for the assessors, the assessors are told to assume that they are writing a report on the subject of the query. If they would like to use any information contained in the document in the report, then the document should be rated as relevant. The assessors are instructed to judge a document as relevant regardless of the number of other documents that contain the same information. The assessors are also warned about single word queries. Though such queries are not prohibited, in these cases the system does not give the user an option to evaluate the result document. The topics of the searches are relatively broad and are defined by the assessors - as much as the imported knowledge base permitted.

6 Result

The Figure presents the changes in results’ positions. Blue horizontal bars denote initial result position. Green vertical bars denote changes in results’ positions.

![Figure 2: Changes in results’ positions](image)
As the experiment indicates, the distribution of results in a substantial share of tests did not change. Even though in some tests the position of the result became worse (i.e., increased), the average effective change in position totalled 0.7. Hence, the quality of search gradually increased.

7 Conclusion

The experiment demonstrates that it is possible to improve the search results ranking function for a specific knowledge domain using the method of expert evaluation of results’ content and thus updating words’ weights vocabulary.

The main feature of the method is constant improvement of search quality based on everyday operation. The system is taught every time the user evaluates the search result if the reviewed document turns to be useful.

In combination with other technologies of search results optimization the described methods is able to positively shift the final results distribution.

8 Future improvements

The author supposes that more profound examination of the algorithm should be conducted, in order to prove right or wrong the tendency of useful result positions minimalization. The described experiment has several simplifications.

• It used simplified first-tear relevance function $f$.
• The search was conducted over one knowledge domain and the initial values were set empirically.

Therefore, there are several ways of improving the total effect.

8.1 Lexical vocabularies

The experimental system utilized a vocabulary of stop-words in order to eliminate the search query from useless words. The more advanced feature is to use vocabularies of synonyms and grammar forms (stemming). The adoption of these language-specific vocabularies will upgrade the first-tear search by including more relevant documents in the result list. The result list then must be the input to the ranking algorithm described in this article.
8.2 Division into knowledge domains

Corporate knowledge bases often contain several knowledge domains, such as finance and accounting, jurisprudence, technical documentation, specific data accumulated by employees etc. The words’ significance distribution (i.e. weight vocabulary) for each of different knowledge domains is unique. Therefore, the next step in search result optimization is compiling of thematic weight vocabularies. The compilation and adjustment of vocabularies may be implemented in many ways:

- The user may independently choose the knowledge domain for his query. The system uses and updates the corresponding vocabulary.
- The knowledge administrator can set the vector of competence of the user a priori. In this case, after every search result evaluation the system updates all weights vocabularies subject to user’s competence in every knowledge domain.

8.3 Automatic discovery of user competence

Provided that the system has a substantial volume of accumulated knowledge - weight vocabularies, it is able to dynamically update each user’s competence vector. The conclusion of quality of each query may be based on comparison of user’s query with each weight vocabulary. We may suppose that the higher is the total weight of the query, the higher is user’s competence in corresponding knowledge domain. The user’s competence value may become higher or lower after the comparison of query quality with current user’s competence value. The retrospective analysis of user’s competence vector may be valuable for organization’s HR department.

The mentioned suggestions need a profound development and may be subject for further research.

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