TTLS: A GROUPED DISPLAY OF SEARCH RESULTS BASED ON ORGANIZATIONAL TAXONOMY USING THE LCC&K INTERFACE

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Abstract: One of the major problems in the process of Information Retrieval (IR) arises at the stage where the user reviews the results list. This paper presents the latest research in a series of research works that aims at finding the most vital information components, within a list of search results, so as to assist the user in high-quality decision making as to which of the resulting documents are included within the sought after results of the search task We propose here a new model for displaying the results named TTLS (Taxonomy Tree & LCC&K Snippet). The experimentation setup included execution of different search tasks by a group of 60 participants. The tasks were performed via the BASE and TTLS interfaces. From the resulting times comparison it is clear that the execution times of tasks done via the TTLS interface is shorter that those done via the BASE interface. It can be seen that in the BASE interface it was needed to open more documents in order to locate the relevant information than in the TTLS interface. It turns out that the majority of users (77%) prefer to use the TTLS interface.

1 INTRODUCTION

One of the major problems in the process of Information Retrieval (IR) arises at the stage where the user reviews the results list. Most Search Engines (SE) nowadays present the results as a continuous list, ranked by the closeness of the results to the terms of the search query. The deficient ranking of the SEs, in combination with the continuous prolonged list, makes it difficult for the user to locate the relevant information sought after. Besides the large number of answers probably returned as result of the search query, the document entries in the list do not appear in any order of topics, and therefore the process of filtering out the results becomes unwieldy. This process is even harder when pursuing exploratory research tasks, where there is more than a single relevant document, and which necessitates a wide understanding of the listed results.

This paper presents the latest research in a series of research works that aims at finding the most vital information components, within a list of search results, so as to assist the user in high-quality decision making as to which of the resulting documents are included within the sought after results of the search task.

The paper is organized as follows. Section 2 reviews the relevant previously conducted research works. Following, the new TTLS (Taxonomy Tree and LCC&K Snippet) model for displaying the results is introduced in section 3. Section 4 presents the TTLS prototype and the conducted experimentation results. Summary and conclusions are presented in section 5.

2 PREVIOUS RESEARCH

The research literature includes several works intended to investigate the influence of various

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information components on the display of query results. Since these vital information components have already been found and analyzed in the previous research works (Drori & Tamir, 2005; Drori, 2000), and have formed the basis of the LCC&K (Line in Context, Categories & Keywords) research interface, we concentrate here on the innovative addition manifested in the combination of a categories tree with the LCC&K interface.

2.1 Information Components on each Document in Results List

Drori, of the Hebrew University in Jerusalem, Israel, has conducted a series of research works (Drori & Alon, 2003; Drori & Tamir, 2005; Drori, 2000) aimed at finding the information components most preferred by the user and their influence when displayed as part of the search results list. The findings have shown that use of documents titles, lines of text in search context, and keywords, are preferable to displaying the same information without these components. A similar finding has been observed regarding the document categories, and the ensuing model has been realized by the LCC&K interface.

The LCC&K model depends only on the rankings of the list entries and hence can be improved. This is due to the fact that to gain information on the degree of similarity or difference between the listed documents, it is necessary to scan all the documents. The documents associated with the same category can be dispersed along the entire results list. Therefore there is no good overall picture of the relevant categories structure and the dispersal of the documents within.

In research by Ivory et al. (Ivory et al., 2004) it has been noted that users prefer to see additional information components regarding the documents over being able to control the way that the list is sorted. They argue that users feel that the process of finding the answer is more effective when they do not have to access documents that do not answer their search goals. Therefore, the display of additional fields for each document can assist the user in deciding if to access the document at all or not.

2.2 Category-based Interface

In research by Dumais (Dumais & Chen, 2000) it has been shown that interfaces where categories are displayed by the interface are more effective than interfaces that just display the results list. An interface that is built up from categories has been found to be more effective than a comparable interface that includes, as part of the document title, the category that is associated with the document. The users preferred category-based interfaces that have turned out to be faster by 50% in finding the answer.

Category-based interfaces include:

- Grouper (Zamir & Etzioni, 1999) – An interface developed for the meta-search engine HuskySearch, which displays search results in clusters. Each cluster is characterized by phrases that are common to the documents included in it and by several (up to 3) example titles. The motivation was to develop a fast clustering method that is independent of the retrieval engine, so it can be made part of a meta-search engine or an end-station browser. Usability studies have shown though that users do not like clusters that are unordered and inconsistent, preferring a known and structured interface in which the categories are displayed with a uniform level of granularity (Pratt et al., 1999; Rodden et al., 2001).

- Vivisimo (vivisimo) – A meta-search interface that provides clustered results based on dynamic categorization (to the Clusty search engine for example). Such commercial platforms do not expose their clustering algorithms and no usability results have been published for them. Nonetheless, it seems that the Vivisimo categorization method uses common terms, those that appear together in retrievals and in common phrases. The construction of the tree hierarchy is based, seemingly, on a recursive activation of the same method on the subcategories.

- FINDEX (Kaki, 2005) – An interface that generates dynamic categories based on the words and phrases common in the document's snippet. The search component makes use of the Google Web API services. The display is given as a single level tree. Since the algorithm is based on statistical analysis, and there is no reference to the meanings of words, there is no "promise" that the categories will be meaningful. In fact, there are situations where the category names lack context or are incomprehensible to the users.

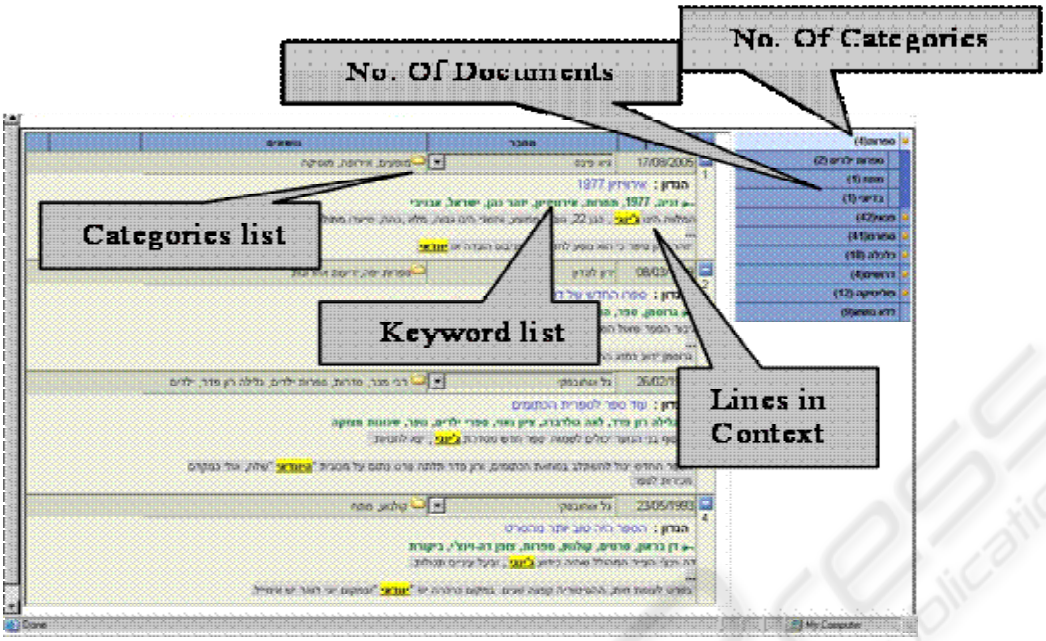

Figure 1: The TTLS interface.

- TLCC (Titles, Lines in Context & Categories) – As part of the research work that led to the development of the LCC&K interface (Drori &Alon, 2003), the advantage of adding categories to the search results list was investigated. The research findings showed significant benefit to the users of the category-based interfaces in varied aspects – it was faster, easier to use, provided higher confidence in the process of finding the answer, and even less misleading compared to the interface having no categories.
- HFC (Hierarchical Faceted Categories) – For a category, whether automatically generated or pre-defined, it is important to concentrate on the use made of it. In recent years, content-based categories have become abundant, and form part of the metadata that can be associated with a document. The Web contains repositories, such as newspapers or medical ones, which in addition to documents include metadata that contain categories. The document added tagging practically enables the logical display of the documents. Taxonomy includes information organized in a way that reflects the major components of the domain dealt with. The list of categories is usually manually generated, and the process of associating the documents with categories can be done manually or automatically. Recently, the HFC method (Hearst, 2006) has been developed and investigated in both the academic and industrial worlds. The main principle of this approach is the use of a hierarchical structure of categories that are associated with facets. Each facet stands for some super category or dimension, for the sake of examining a collection of documents. Each facet is associated with its relevant categories. The HFC structure enables navigation in several ways, as part of a process of "diving" into the results list, where the metadata also assists the user.

3 THE TTLS MODEL

We propose here a new model for displaying the results named TTLS (Taxonomy Tree & LCC&K Snippet) (Mordechai, Drori & Frank, 2007). The TTLS model assists the user in locating, in a short time, the information sought after by focusing on the relevant documents per search task. The challenge is to find the best way to display the results including categories so as to assist the user in locating the relevant documents out of many results.

The main idea is based on exposing the metadata available in the repository as part of the interface, and making use of it to organize and order the results list according to the HFC principles. Such metadata can be used for a "logical view" on the results list, enabling exploratory research tasks that utilize categories to decide on how to advance: scroll

in the results list, refine the retrieval, etc. In addition, an enhanced document snippet could assist the user in deciding if some document is relevant without needing to access it for a deeper check.

The TTLS model proposes to enhance the display of the search results by a combination of:

1. Categories-based grouping of documents – categories are based on manual tagging that was done based on terms of an organizational taxonomy. The categories are organized by facets, where each facet is a main branch of the taxonomy tree. The tree branches are ordered by an algorithm described below.
2. Line in Context – relevant lines of text in the search context are displayed as well as the categories and keywords of the document snippet, based on the previously defined LCC&K interface.

A prototype implementing the TTLS model is shown in Fig. 1.

The advantages of the proposed model:

- The user gets information on the dispersal of documents between the various categories and facets.
- The display of the structure directs toward focusing on a specific category without requiring the explicit scanning of the documents' titles.
- The document snippets help in comprehending the document contents so as to decide if the document is relevant.

3.1 Ranking of Categories

To decide the order of the categories in the taxonomy tree we use the common **tfidf** (term frequency – inverse document frequency) method. This method is based on the Vector model for each document and is a popular ranking method since it's considered a simple and fast method (Baeza-Yates & Ribeiro-Neto, 1999).

It is proposed here to do an analogy of terms in the original equation (words in documents) to our terms (topics in retrieval), as follows:

Frequency of word in document ~ Frequency of topic in retrieval

Frequency of word in repository ~ Frequency of topic in repository

Hence:
Importance of category C_i in retrieval q:

$$tf_{Ci,q} = 0.5 + \frac{0.5 * f_{Ci}(q)}{\max_j f_{Cj}(q)} \quad (1)$$

$f_{Ci}(q)$ – Number of documents associated with category C_i in retrieval q

Importance of category C_i in repository D:

$$idf_{Ci} = \log \frac{|D|}{f_{Ci}(D)} \quad (2)$$

$|D|$ – Number of documents in the repository

$f_{Ci}(D)$ – Number of documents associated with category Ci in repository D

And in summation for each category we will get its weight by multiplication of the two parameters:

$$W_{Ci,q} = idf_{Ci} * tf_{Ci,q} \quad (3)$$

4 THE TTLS PROTOTYPE AND EXPERIMENTATION

The goal of the prototype is to show that the proposed TTLS model does solve the aforementioned problem. To investigate and evaluate the new method, an experiment was setup to compare the TTLS model/interface to a base model/interface that currently exists in an information retrieval system. The base model/interface, named here BASE, displays only a ranked results list. The purpose of the experiment is to check if and how the suggested solution is different from the extant solution in aspects of response times, number of documents to be scanned, and several subjective measures.

The repository referred to has manual pre-tagged documents. As part of the experiment, response times and correctness of the answers were measured (as objective data), as well as, for example, ease of use and effectiveness for users (as subjective data). As the experiment showed, the TTLS model does serve the users better than the previous one.

4.1 Experimentation Setup

The experimentation setup included execution of different search tasks by a group of 60 participants. The tasks were performed via the BASE and TTLS interfaces. For the sake of the experimentation, a repository of around 400 documents that are relevant to the search tasks was constructed. The original repository includes millions of documents that were manually tagged, and out of them, the experimentation repository was filled with the documents that can satisfy the search tasks.

The experiment compared two ways of displaying the results based on a pre-defined set of queries and the pre-prepared collection of relevant answers. The categories in the TTLS interface were presented based on the structure of the organizational taxonomy.

The search tasks were pre-defined based on the approaches of (Drori, 2000) and (Dumais et al., 2001) in a similarly conducted experimentation. The reasoning of this approach is to neutralize the variance that exists between search capabilities of users of differing levels, so as to enable the measuring in a "clean" way, without noises, of the stage of users scanning the results, which is expected to improve. This limitation will be removed, of course, in a full implementation of the model. The types of search tasks were taken from the daily contents world of the users so as to reflect real work and create motivation for utilization of professional knowledge by the user in executing the task.

The efficiency of search and the user satisfaction were checked via use of two dimensions: objective data, i.e., response time and correctness of answer, and subjective data, i.e., ease of use, effectiveness for users, level of confidence, satisfaction rate, and the relevancy of the information components. After completion of tasks in each of the interfaces, users filled in a questionnaire. A computerized process was used for the questionnaire input that was stored into a database. The experimentation setup also logged information in a way that enabled exact analysis of response times and documentation of all operations done by the experiment participants.

4.2 Experimentation Process

As part of the experiment, a repository including relevant documents and screens was constructed. The experiment was run one-on-one between the experiment conductor and a single participant at a time. There was an option to perform a dummy task before the real experiment. The time given to the participants was unlimited. The correctness of the result(s) was verified by the experiment conductor while it was run.

4.3 Experimentation Tasks

The experimentation included four search tasks out of the contents world of the users. Two of the tasks were more focused – finding a document containing the needed information, and two tasks were research oriented – retrieval of information contained in several documents.

It should be noted that this experiment was run at a government installation so the explicit scenarios used and the actual contents can not be revealed. Nonetheless, we will demonstrate the style and nature of queries using similar search tasks from the culture and leisure domains:

- Example of a focused query – in what year did Izhar Cohen win the Eurovision contest?
- Example of a research oriented query – find exemplary documents that mention the relation between the actor Moni Moshonov and the Habimah Theater, and in which of its plays was he an actor?

The position of the relevant documents in each one of the four tasks is detailed in Table 1. The order of retrievals was balanced in a random manner so that each task was done by different users in different ways.

Table 1: Position of the relevant document(s) in the original list of documents.

Task	Position of relevant document(s) in original list
Focused 1	13 out of 33
Focused 2	6 out of 95
Research 1	99, 100, 103 out of 109
Research 2	63, 73, 85, 90, 91, 92 out of 119

4.4 Experimentation Outcomes

We use the following parameters for the experiments:

- MEAN – average received.

- SD – standard deviation of the MEAN of all observations. The smaller the SD so is the distribution of the data, and the MEAN is more meaningful.

- P – probability that here is the percentage of likelihood of chance that the researcher is willing to risk and accept the results.

In referencing Table 2, it can be seen that for each of the parameters, besides "Amount of information shown", the TTLS model/interface has a clear advantage.

4.4.1 Comparison of Execution Times

From the resulting times comparison (see Fig. 2) it is clear that the execution times of tasks done via the TTLS interface is shorter that those done via the BASE interface. For the exploratory research tasks, the gap in the execution times is even larger. In the focused tasks the gap was between 13% to 44% while in the research tasks the gap turned out to be between 39% to 240%!

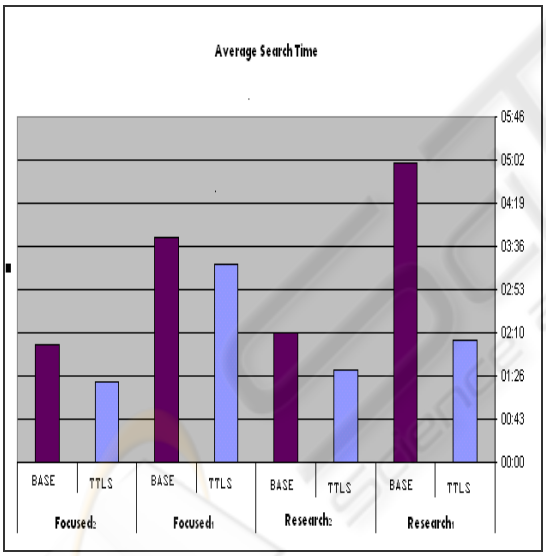

Figure 2: Comparison of execution times of task.

4.4.2 Number of Documents Accessed

The enhanced document snippet is designed to assist the user in deciding whether a document is relevant without the need of opening it. Each access of the user to a document was logged and a comparison between the two approaches was done. It can be seen that in the BASE interface it was needed to open more documents in order to locate the relevant information than in the TTLS interface. In the BASE interface, 6.7 documents on average were opened while in the TTLS interface the comparable number was only 2.2. In general, from the analysis of the questionnaires, it turns out that the majority of users (77%) preferred to use the TTLS interface "most times" and "always".

Table 2: Results of t-test for checking variance between the two interfaces.

Tested Variable	**Interface MEAN (SD)**		**Significance T-test P<0.05**
	BASE	**TTLS**	
Comfort feeling during retrieval process	2.71 (1.05)	4.41 (0.76)	yes
Amount of information shown	3.40 (1.06)	3.45 (0.62)	no
Relevancy of information associated with title	2.50 (0.89)	4.33 (0.54)	yes
Misleading information associated with title	2.63 (0.80)	2.06 (0.60)	yes
Confidence feeling during use	2.78 (0.86)	4.46 (0.53)	yes

4.4.3 Explanation of Outcomes

When the user scans the beginning of the list and does not find what is sought after, the ranked taxonomy tree is approached for assistance. When the user arrives at the requested category or one that looks like it is relevant, the document snippet enables a relatively fast decision making on the relevancy of the document, based both on the associated categories and on the text lines in search context. Consequently, the number of documents that the user opens until what is sought after is found

is smaller and the process of information retrieval is considerably shortened.

5 SUMMARY AND CONCLUSIONS

To overcome the hardship of effectively handling a large number of results, we have proposed the TTLS model that combines several techniques for display of the results including a ranked taxonomy tree and an enhanced document snippet. The goal of the prototype built was to exhibit that the proposed model does solve the above problem. The prototype was used to investigate both execution times and correctness of answers, as well as effectiveness and ease of use by users. It has been found in the experimentation that the TTLS model can indeed serve the users better than the previous models.

In order to increase the effectiveness of the model, and respond to additional needs of the users, it is highly recommended to invest in further improvements, enhancements and investigations of the model and prototype. Further extensive experimentation is needed with more participants so as to accumulate enough results that are amenable to reaching wider conclusions by use of statistical tools. Another research direction is the automatic generation of categories that as of now are manually associated with the documents. Moreover, the compatibility between the manual catalog and the automatic one in utilization of extant algorithms for document cataloging in given contents worlds can be investigated.

To summarize, the proposed method of ranking the branches of the taxonomy tree is innovative. This is in addition to other parts of the user interface that have been proposed before, each on its own, such as the display of taxonomy tree, display of facets, or display of snippets based on the LCC&K model. The integrated display of these components in the TTLS model, and the evaluation process with real users, constitute the contribution, presented in this paper, to the information retrieval field.

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