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MedTextus: An Ontology-enhanced Medical Portal

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Abstract

In this paper we describe MedTextus, an online medical search portal with dynamic search and browse tools. To search for information, MedTextus lets users request synonyms and related terms specifically tailored to their query. A mapping algorithm dynamically builds the query context based on the UMLS ontology and then selects thesaurus terms that fit this context. Users can add these terms to their query and meta-search five medical databases. To facilitate browsing, the search results can be reviewed as a list of documents per database, as a set of folders into which all the documents are automatically categorized based on their content, and as a map that is built on the fly. We designed a user study to compare these dynamic support tools with the static query support of NLM Gateway and report on initial results for the search task. The users used NLM Gateway more effectively, but used MedTextus more efficiently and preferred its query formation tools.

1. Introduction

Many research projects focus on retrieving relevant information online. On one hand, they focus on helping users retrieve a small set of highly relevant documents. On the other hand, they focus on supporting users with a manageable overview of a large collection of information. Browse and query formation support as described by Sutcliffe and Ennis would belong to the first category; evaluation support to the second [13]. Because these research streams are complementary, we have integrated tools belonging to each of them into our online portal. In the following, we discuss related research on user support tools, our online medical search portal MedTextus, the user study, and our conclusions and future research.

2. Browse and Query Formation Support

Browse support helps users formulate information requests [13]. It can consist of concept maps, thesauri, or ontologies used to help formulate search requests. The Unified Medical Language System (UMLS) developed by the National Library of Medicine (http://umlsks.nlm.nih.gov/) is a medical ontology that is very valuable for this type of support. Its Metathesaurus provides term definitions in different languages and associates each term with underlying concepts. Query formation support helps with the actual search, e.g., keyword based searching or querying by example are the most straightforward examples. Dynamic queries use visualization to continuously update users on their results set while forming a query [1]. Query expansion can be used with good results for resource selection or to search individual databases [10]. It is helpful to improve retrieval performance and can be done automatically or manually by users, and at different stages of a search.

3. Evaluation Support

Evaluation support helps users evaluate search results [13], e.g., search engines do this with relevance-based rankings of the results. With meta-searching, results from different sources have to be combined, which is often difficult because the results should be combined and re-ranked. The local similarity adjustment method recombines by adjusting the similarity given by the individual databases based on additional information about, for example, the source; the global similarity estimation method re-estimates all the documents [9].

Other evaluation approaches provide previews of individual elements or overviews of the collection. A preview is extracted from the original item and acts as a surrogate for it. It is effective when it communicates to the user sufficient information about individual information items. An overview is based on a collection of objects and is effective when it provides an immediate understanding of the size, extent, and content of a collection of information items [4]. There are several different types of previews and overviews. For example, a summary is a preview that allows users to sample the information before deciding to view the complete document. Woodruff et al. [14] compared textual and graphical (thumbnails) summaries and found that the best of them combined both types. Shneiderman [11] provides a taxonomy of overview methods. One-dimensional data types include lists such as those that result from a digital library search. Two-dimensional data types are maps or layouts. These can be geographical representations, orabstract spatial displays of document collections, e.g., a self-organizing map (SOM) to represent document collections [6]. Multi-dimensional types retrieve data from databases and let the attributes become dimensions. For example, hieraxes provide visual overviews of thousands of items by combining categorical and hierarchical axes in two-dimensional displays [12]. Temporal structures use timelines and trees. Networks explicitly display the relations between elements.

4. User Support Tools in MedTextus

MedTextus is a medical meta-search portal that provides dynamic browse, search formation, and evaluation support to the users (http://ai.bpa.arizona.edu/go/medical/MedTextus.html). By making the support dynamic, i.e., dependent on the user query, we believe it will be more relevant and useful. To start a session, users can choose 5 databases: Medline, the Merck Manual, the Database of Abstracts of Review of Effectiveness, National Guideline Clearinghouse, and the American College of Physician's database. Search terms can be combined with Boolean operators (And, Or) and the number of documents to be retrieved from each database can also be chosen: 10, 20, 30 or 50 documents.

4.1. Query-specific Suggested Keywords

To improve retrieval performance, users can add system-suggested terms to their queries. Synonyms are retrieved for each keyword from the UMLS Metathesaurus. To suggest new keywords dynamically, we implemented a concept mapping algorithm, evaluated earlier by domain experts [7], and are testing it for the first time with actual users. The mapping algorithm uses the UMLS Semantic Net to dynamically establish a suitable context for a user query. It retrieves concept names for user keywords from the UMLS Metathesaurus and also the semantic types from the UMLS Semantic Net. The original types, closely related types, and their relations, form the context of the user query. Potential new keywords are automatically retrieved from a co-occurrence based thesaurus. The technique to build the thesaurus was developed earlier [2]. For MedTextus, we applied it to the entire Medline collection. For each user keyword, related terms are retrieved from the thesaurus, combined, and then compared with the query context. The fit between terms and context is determined by mapping each thesaurus term to the context. Terms with the highest combined relevance scores from the thesaurus and acceptable context mapping are presented to the user. Additionally, MedTextus provides unfiltered co-occurrence terms that are retrieved for each individual term and re-combined. The top terms are selected. For example, for "whiplash" and "head and neck injuries," filtered related terms were "accidents, traffic," "cervical zygapophysial joints," and "motor vehicle accidents," and co-occurrence terms were "cervical vertebrae," "cervical zygapophysial joint pain," "patients with chronic neck pain," and "cervical spine." Users can checkmark individual terms to be added their query (Figure 1-A).

4.2. Query Specific 1D Folder Overview

MedTextus provides evaluation support with three types of overview. The documents retrieved in response to a user query can be viewed as a list for each database. The list shows the document title and bibliographic data. Each title is linked to the document in the original database. The results are further categorized and displayed in dynamically created folders. These folders combine the results from the different databases. To categorize the results, each document is preprocessed to extract relevant medical text. Then the medically relevant noun phrases are extracted, folder labels based on the occurrence of phrases are selected, and each document is assigned to at least one folder. The folders are currently ordered alphabetically and shown with the number of documents they contain (Figure 1-B). Clicking on a folder brings up a display of the documents contained in the folder and their links to the original database.

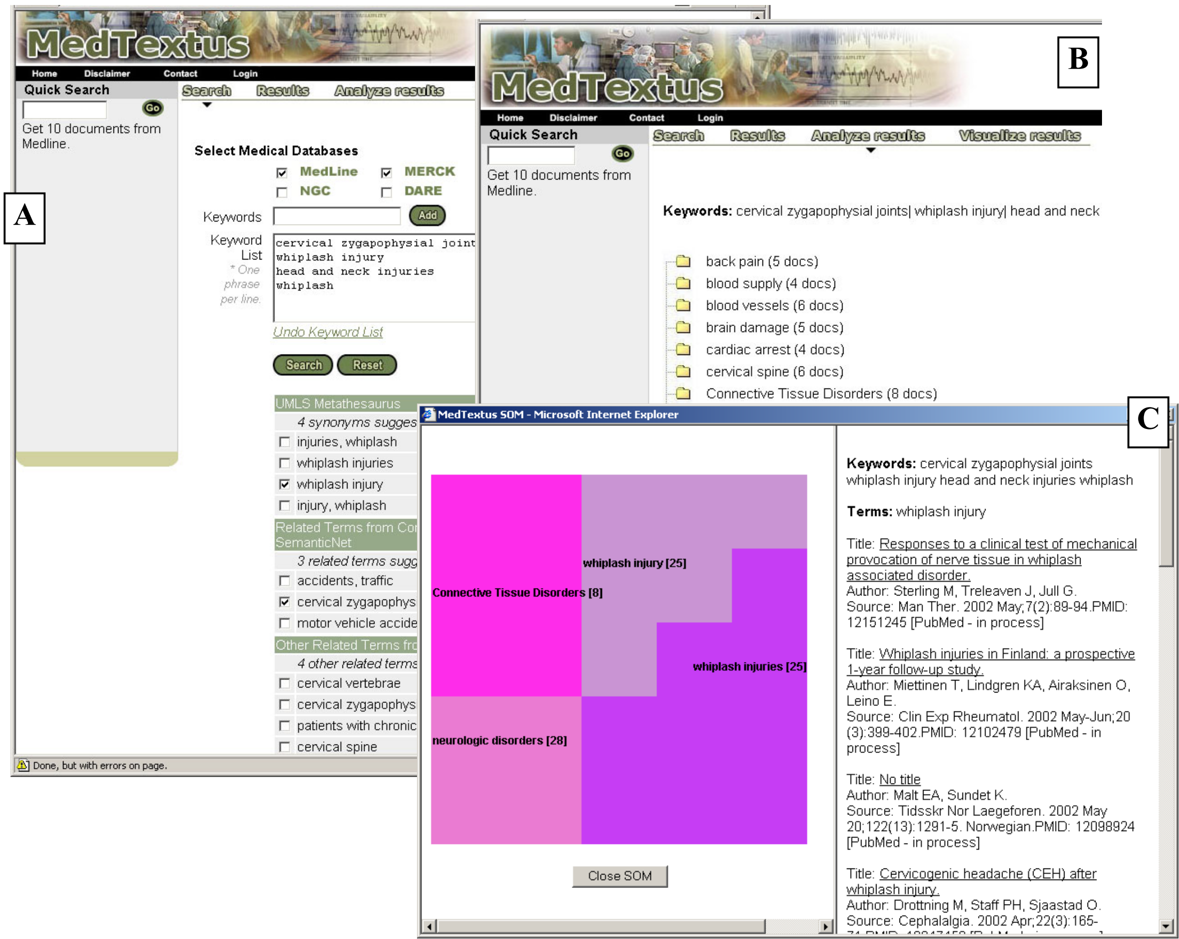

Figure 1: MedTextus provides users with suggested synonyms and related keywords (A), categorizes the results in folders (B) and provides a visual overview of the results (C).

4.3. Query Specific 2D Map Overview

Search results from the selected databases are also combined and dynamically categorized by a self-organizing map [3, 6]. The algorithm uses medical noun phrases to process the content of each document and builds the map on the fly for the combined results. This is accomplished by placing each document in a cell on a grid based on the similarity between and within the cells. Each cell forms a category of documents. We display the categories as an abstract 2-dimensional map. When users click on a region of the map, the documents belonging to that region are shown and users can follow the links back to the document in the original database (Figure 1-C).

5. User Study

5.1. Purpose and Research Questions

We believe search and browse tasks will benefit from diverse support tools. In particular, we believe that overview tools will be more useful for browse tasks, that keyword tools will be more useful for search tasks because they focus the search at initiation, and that query specific overviews will be more useful for search and browse tasks than static overviews. To study the differences between the approaches, we compare results of using MedTextus with outcomes from using NLM Gateway (http://gateway.nlm.nih.gov). NLM Gateway was chosen because it is a state-of-the-art search portal which provides support tools that, although static, are similar to MedTextus. NLM Gateway suggests search terms by mapping individual keywords to Mesh trees and the UMLS Metathesaurus. It provides an overview of the results with 5 predefined folders and the number of documents they contain. Suggested keywords and folders do not change with a user query, i.e., the same keywords are retrieved for a term regardless of additional keywords in the query. In contrast, the suggested keywords, folders, and map of MedTextus are dynamic; they change relative to the user query and result sets.

5.2. Design

Users were to perform either a search or a browse task with both portals in a controlled experiment. Table 1 provides an overview of the design. We report here on the search task data for 13 users. Twelve published questions [5] were randomly assigned to users, tasks, and portals. For the search task, users were asked to answer the question (yes/no) and find supporting abstracts. We awarded $100 to the subject who identified the correct answer to a question with the most abstracts. The user session started with a short background questionnaire. Then a search portal was presented to the user together with the task. For both portals, we demonstrated each component using the keyword 'cancer.' The facilitator kept notes on the actions of the users and the start and end time. Users indicated their answers on a separate answer sheet. Following each task, a second questionnaire was presented onwhich users rated usability.

	MedTextus	**NLM Gateway**
Search Task:	Group 1	Group 1
Browse Task:	Group 2	Group 2

Table 1: Overview User Study Design

We measured effectiveness, efficiency, and usability of each portal. Effectiveness is the number of correct answers combined with the support for correct answers. Efficiency is the time users spent on a task, the number of searches to find the correct answer, and the number of abstracts read to find the correct answer. Usability was measured by a questionnaire comprised of three parts: a general usability questionnaire developed by Lewis [8] and an in-house questionnaire designed to evaluate browse & search (Boolean option and query expansion elements) and evaluation support (results lists, folders, and maps). For example, to evaluate synonyms, three questions are asked and the scores combined: "I found the ability to add synonyms useful," "I found the synonyms provided relevant," "I found it easy to add synonyms to my search." All questionnaires used the same 7-point Likert-scales, with a lower number indicating a better score.

5.3. Results

Thirteen subjects participated in the search task. They were medical students, professionals, or librarians. Although 3 subjects said they knew the answers to 2 or 3 questions, we did not exclude them from the results since we required users to find supporting abstracts.

Table 2 shows the results for effectiveness and efficiency. The percentage correct answers is the number of correct answers found by all users with a certain portal. The average support is the average number of documents found by the users that indicated the correctness of the answer. The percentage correct answers was higher with NLM Gateway than with MedTextus; however, more support for correct answers was found with MedTextus. Additionally, it took less time and required less searches to find the correct answers with MedTextus. Less abstracts were read with NLM Gateway to find a correct answer. Due to the limited number of participants, the results are not significant.

Table 3 provides an overview of the usability evaluation and shows that the users liked both search interfaces. For general usability, NLM Gateway scored better. In MedTextus, the specific query formation tools were preferred. Scores on the individual support tools indicate that users preferred the browse and search formation support of MedTextus. We noted that the users self-rated searching expertise, based on the background questionnaire scores, correlated positively with the general usability scores of MedTextus ($p < .05$), indicating that the users who considered themselves more expert in online searching preferred the MedTextus search portal more.

(n = 13)	**MedTextus**	**NLM Gateway**
EFFECTIVENESS		
Percentage Correct Answers:	50	81
Average Support for Correct Answers:	1.6	1
EFFICIENCY		
Time to find correct answer (minutes):	8.3	8.8
Number of searches to find correct answer:	2.4	3.3
Number of abstracts read to find correct answer:	3.8	2.7

Table 2: Overview of Effectiveness and Efficiency Results for the Search Task

(n = 13) 7-point Likert Scales, 1 is best, 4 is neutral	**MedTextus**	**NLM Gateway**
Total General Usability:	3.2	2.6
Subscale - system usefulness:	3.0	2.5
Subscale - information quality:	3.0	2.6
Subscale - interface quality:	3.3	2.6
Total Search Support Usability:	2.3	2.7
Subscale - synonyms:	2.3	3.6
Subscale - related terms:	2.4	3.1
Subscale - modifiers (and, or):	1	1.8
Total Evaluation Support:	2.8	2.4
Subscale - listing results:	2.5	2.3
Subscale – folders:	2.7	2.6
Subscale – map:	3.5	-

Table 3: Overview of Averaged Usability Results for the Search Task

6. Discussion

The purpose of this study was to compare dynamic and static support tools for browsing and searching. The current results provide strong indications that the effectiveness of NLM Gateway based on the number of correct answers was higher. Since we did not alter the order in which the documents were returned, and users did not change the options to retrieve more than 10 documents per database or to search more than 2 databases, we believe NLM Gateway's showing more correct answers reflects the ability to consider a larger number of instances: 20 documents per page with the option of seeing more results without performing a new search. In MedTextus, we plan to increase the default for the number of results returned per search. The results also indicated that efficiency was greater with MedTextus. It took less time and fewer searches to find a correct answer. The usability results indicate that users liked both interfaces. For general usability, NLM Gateway was preferred, but the specific search components in MedTextus were preferred.

We reported on the initial data from 13 users and plan to add more data to achieve sufficient statistical power for this design. We will also acquire user data for browsing tasks. Based on the lessons learned from the search task, e.g., users do not often change default values when searching, and the browse task, e.g., ordering the folders alphabetically or according to size is preferred, we will optimize MedTextus.

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