Approaches for Web Search User Interfaces

How to improve the search quality for various types of information

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***Abstract*— This paper describes approaches used by web search tools to communicate with users. With respect to different kinds of information resources, we examine interactive interfaces that use textual queries, tag-focused navigation, hyperlink navigation, visual features, etc. Among others, we introduce the design vision and describe the implementation of a visual-interface based on concepts of query token network and the WordNet ontology.**

Keywords- web search; search problems; query modification; synsets; ontology; WordNet

I. Introduction

Following Guha et al., there are two major forms of search: research and navigation [1]. In research search, the search engine input is some phrase request. The research searching process is usually aimed to locate a number of documents containing information that users are trying to find (e.g. scientific articles, terms, definitions, cooking recipes, sightseeing reviews, etc.). This kind of search is a semantically oriented search. In navigational search, people use a search engine in a capacity of navigation tool so as to discover documents that the user is interested in. Sometimes at the start of the searching process users don't know exactly what kind of document they are trying to locate. They expand subject domain boundaries and then narrow them during further search within the limitations of the expanded knowledge area. In this case it is difficult to apply semantic search concepts because the query semantics may not be expressed so well. Some researchers also use the term "discovery search" describing the process of searching based on query variations to better reveal the context of the search [2].

Web search navigation systems may be supported not only by navigation between different web pages, but by navigation through the ontology terms (e.g. WordNet) in the process of composing the search query [3].

The quality of web search results depends not only on the quality of the search engines and algorithms they rely on, but also on the quality of user queries, as well as on user interface facilities allowing better expression of the users' intentions. On web sites and in existing software there are numerous approaches applied for both information presentation and for information retrieval. Effectively, different approaches correspond strongly to types of information that users are looking for. For text based documents (such as scientific papers, encyclopaedic articles, books and so on) one could mention many tools that simplify and regularise the search process. However, web users still do not have enough applications to assist in finding music, images, video, or other types of information generally called non-classical search problems.

II. Web Search User Interface: Types and Sites

There are at least three aspects that relate to good search system construction:

- Using good searching algorithms.
- Implementing intelligent interactive tools supporting query refinement by expansion or modification.
- Providing a friendly and flexible user interface assisting users in the process of navigational searching.

This paper is not focussed on algorithms and search engines, so special attention is paid to user-oriented issues.

In addition to the standard edit box used to enter queries, searching services often support various features aimed to better express different aspects, attributes and artefacts of the searching process. As many as there are, we mention the following as example:

- Special syntax for query languages.
- Query term sense disambiguation and sense selection tools.
- Query term weighting tools.
- Features that allow dealing with non-linguistic text queries like chemical equations, mathematical expressions, samples of software source code, etc.
- Visual representation of the query term relationships (for example by means of interactive token networks)
- Displaying query term relationships with ontological terms and concepts for better query modification with regard to semantic relatedness.
- Visual interfaces using clickable graphs or tree based structures representing associations between web pages relevant to the search query.
- Web tagging (e.g. in the form of tag clouds).
- Hyperlinks.
- Special tools for entering non-textual queries (e.g. virtual musical instruments, audio or image samples).

In this section we made an attempt to review different approaches to build web search user interfaces that fit either a particular search area (e.g. geography, literature, mathematics, chemistry, etc.) or types of target search information (e.g. text, media, equations, maps, addresses, etc.).

A. General Purpose Search Services

Many web sites that may be considered as a sort of web search "terminal" are created on the basis of rather traditional approaches, including an encyclopaedic approach (as in Wikipedia) improved by strong document cross-referencing, and hierarchical classifiers (as in Google.com, Yahoo.com, Yandex.ru, etc.). Some of them (for example, www.infoseek.com) support query refinement by entering additional keywords to the list of resources that have already been found. Some search engines may be specialized in order to manage limited documents types (images, video, software products, news, software source code, etc.).

At www.hakia.com, a feature was implemented to encourage users to compare Hakia's own search results with pages found by Google, Yahoo or MSN search engines. The search results were then presented in separate frames within the same web browser tab. This is a new approach rather than a new idea as, this service directly implements activities users often do themselves, when they open separate web browser tabs or windows to carry out the same search.

The web search tools are not limited by search engines (containing databases of indexed web pages and implementing different information retrieval algorithms). They also include meta-tools as kinds of proxies to different search engines (in this sense, Hakia.com is a kind of meta-tool), catalogues as kind of hierarchical structures, and specialised search software (e.g. web crawlers automatically browsing web pages and creating indexes and dictionaries).

When we use a search engine we construct and modify queries. The search itself is mostly automated, and Query creation and modification, relevance and quality analysis are partially automated [4, 5, 6].

As it is often declared by creators, most search engines aren't conventional searchers, but semantic searchers. This puts in mind the annoying TV adverts about super washing powder that is 10 times better than normal washing powder, but nobody knows anything about what "normal washing powder" means.

We examined a variety of existing search engine services, and here is a list of main features that make the search engine semantic:

- Paying attention to morphological variations of a query term;
- Using dictionary information to match term synonyms;
- Expanding queries with the use of generalised terms retrieved from ontologies (e.g. WordNet);
- Knowledge or concept matching by using not only "traditional" ontologisms but also such knowledge bases as Wikipedia;
- Time matching (paying attention to absolute and relative time indication, e.g. last year, this month, etc.).

Making search engine semantic does not necessarily mean conducting complex semantic analysis of the query and/or revealed documents, but using the statistical information about web pages users visit or ignore. The interface of most search engines often forces users to select an item from the query completion list (called "smart predictions" by Google). To save time, users may even discard their primary intentions and simply choose the complete phrase which seems to have been sensed with regards to their searching goals. Collecting information about visited pages may be used to rearrange web page snippets for another user who has selected the same query from the hint list.

B. Searching Specific Information

There are alternative approaches. For example, at Nigma.ru user queries are interpreted with special attention to mathematical and chemistry computations, allowing users to obtain solutions for mathematical or chemical equations (as shown in Fig. 1).

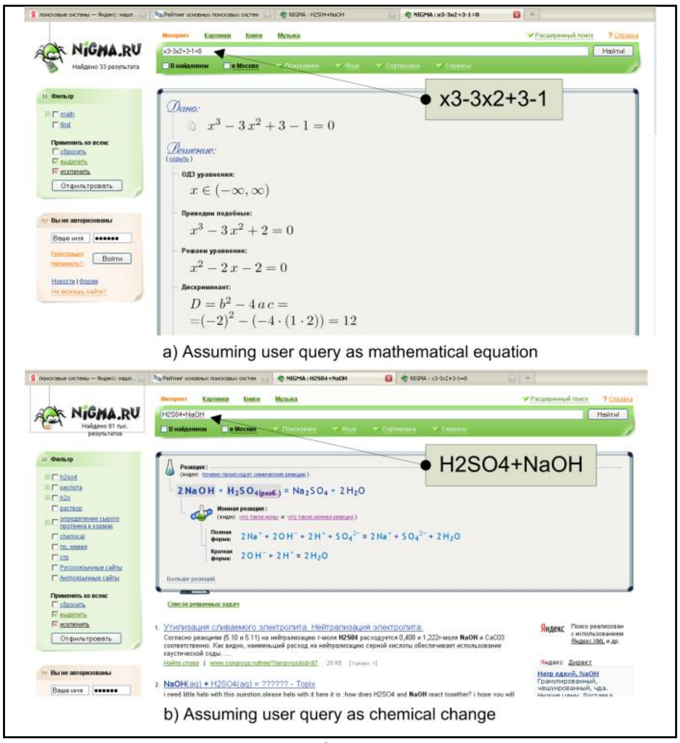

Fig. 1. Nigma.ru approach to interpreting user queries

C. Techniques to Improve Search Navigation

Considering search navigation techniques the following implementations need to be mentioned:

- Wolfram Alpha web browser plug-in implements the idea of what they call "knowledge computability" [7]. First, the Wolfram search engine tries to define the field of knowledge (e.g. geography, metric systems, or something else). Then, it retrieves information with respect to this specific field (as the two examples in Fig. 2 show). Used together with regular search engines it gives to the user a complementary view of the information relevant to the search requested.
- TouchGraph Google Browser Java applet is kind of graph based search tool (see Fig. 3). It explores site dependencies in the form of editable graphs together with clickable hyper references and referenced site summaries [8].

- Tag clouds are nowadays widely used in most search services. Originally they were implemented for image storage and discovery as can be seen in such popular services such as Flickr (www.flickr.com) and Yandex Photo (http://fotki.yandex.ru/) [9]. This approach has been successfully applied to more general search tools such as Mozilla Firefox add-on components CloudLet and DeeperWeb (see www.getcloudlet.com and www.deeperweb.com respectively). To sum up, tag clouds are considered to be one of the basic techniques to improve the user interface in information retrieval and searching systems [10, 11].

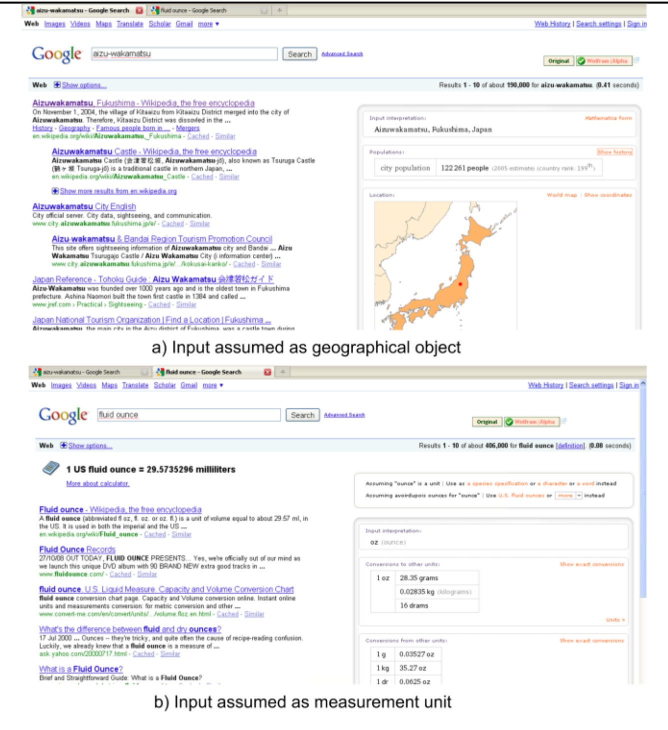

Fig. 2. Wolfram Alpha's knowledge computability

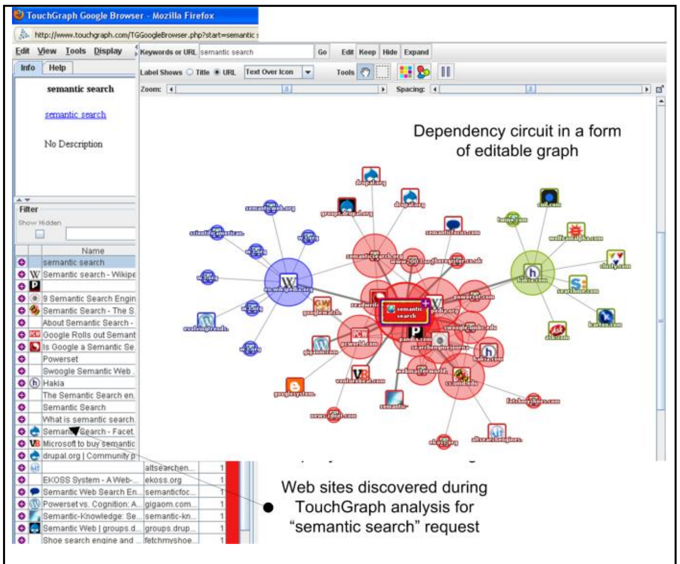

Fig. 3. Representing site dependencies in the TouchGraph service

Friedman examined different tag cloud representation styles including indexed tag clouds, font-size-weighted tag clouds, colourful tag clouds, and shaped tag clouds [12]. We can also add to this the tree-based style as another typical way of structuring access to the different information layers (e.g. operating system file and folders, software project properties, document structures, etc.).

D. Approaches Based on Term Relationships

There are also approaches mostly aimed at helping users to more flexibly modify queries by using elements of semantic analysis (e.g. sense disambiguation, ontologisms, cognitive synonyms, etc.).

One of the evident pitfalls of search engine usage is the difficulty in creating good queries. Users handle words as semantic units, in contrast to a search engine that usually interprets words as lexical units. A semantic tree is one formalism that could be used to extract possible meaning from the query terms. Comparing the semantics computed in a formalised way with the query sense the user implies, may help users in estimating the quality of the query and lead them to further modify the query by using terms extracted from the tree.

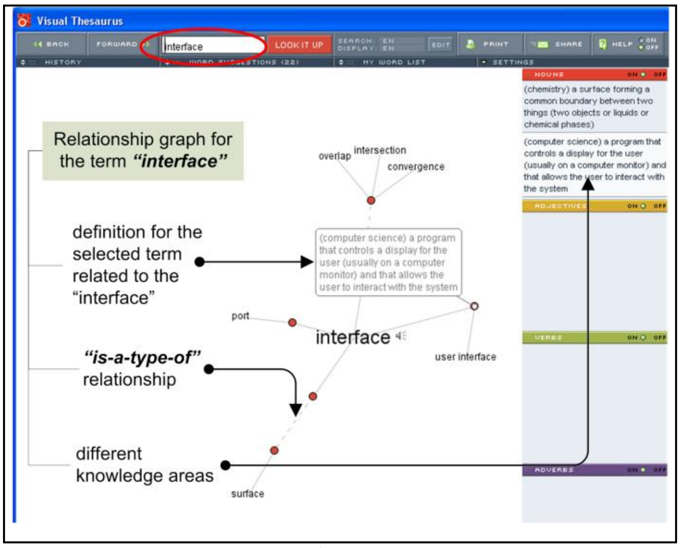

Fig. 4. Thinkmap approach for visualising word relationships

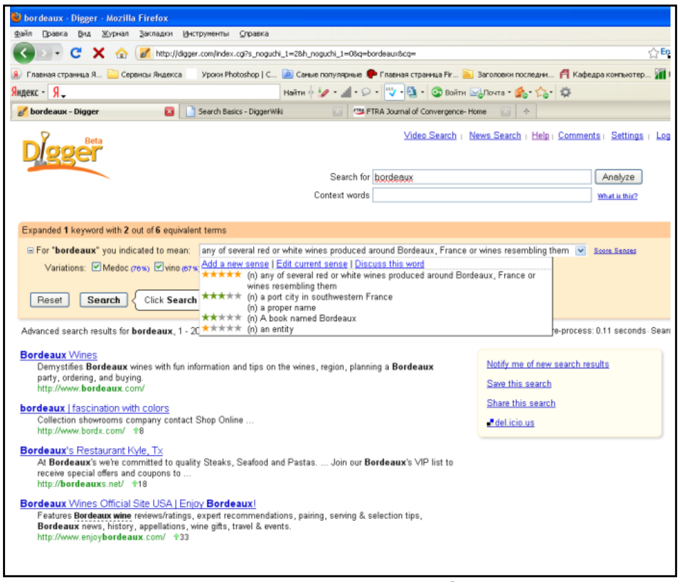

Fig. 5. Digger semantic searcher

Here are two examples of products based on using term relationships:

- Thinkmap Visual Thesaurus shows word relationships on the graph and supports a wide range of relationships, including "type-of" and "hype-of" associations, synonyms, antonyms, derivative forms, etc. (see Fig. 4) [13]. It is not a kind of search tool, but it can be used together with search tools to assist users in constructing better queries.

- Digger.com semantic searcher is especially interesting to us. If we compare the illustration presented in Fig. 5 to the description of WordNet's basic relationships appearing in the section III(A) of this paper, we can see obvious similarities between the terms proposed by the Digger semantic searcher and the terms from the WordNet taxonomy trees, as is shown in Fig. 6 and Fig. 7.

Expecting some criticism for many of the web site screenshots presented in this section, we nonetheless decided to spend about one page to introduce examples of implementation, showing different approaches to *visualise* the search process.

E. Using The Semantic Web

The context of the search problem may be extended with the help of Semantic Web technologies, since the main idea of the Semantic Web is to create machine-readable meta-data for existing documents in order to improve knowledge retrieval. For that aim, ontologies are considered one of the key Semantic Web formalisms [14].

Hendler mentioned that there are at least two semantic search capabilities [15]. The first is the attempt to provide more information results than are typically returned by a regular search engine. Rather than simply identifying a useful page, these systems try to pull out the information from those pages that might be useful, and to make this immediately apparent. Thus, the search agent www.semanticwebsearch.com uses the principle, "If we are unable to understand what our users say, let's lead them to say what we can understand". In the process of constructing the query, users are allowed to choose a resource type or to define property values related to the Semantic Web meta-data.

The second capability offered by the semantic search is the attempt to help the user identify further searches that may be more useful (exactly what we do in our work).

III. LEARNING COGNITIVE SYNONYMS, OR SYNSETS

In this section we examine the main sources that affect our research, including cognitive synonym usage in linguistics, information retrieval and processing, tree-based term relationships representation, and query modification.

A. Importance of Learning Synonyms in Linguistics

In linguistics and its applied fields the learning of synonyms is important for language analysis with regard to a number of issues:

- Expressing concepts, language style perception and description, and language etymology learning [16];

- Investigation of relationships between words for language study and a better understanding of the language structure [17, 18];

- Discovering synonymic attractions and sets of synonyms as a method of language cognition and world objectification [19];

- Learning speech genres as a part of an anthropocentric approach in cognitive linguistics [20]

- Text semantic analysis and machine oriented document processing, such as web document semantic analysis [4], summary generation for better document selection and constructing of semantic metrics for better ranking of documents [5].

The cognitive synonym concept is based on organising words in sets of synonyms, or synsets. For nouns the basic relationships are the following:

- Hypernymy (generalisation): the word ***A*** is a hypernym of the word ***B*** if ***A*** expresses more general concept of ***B*** (e.g. Bordeaux is kind of wine, therefore wine is a hypernym for Bordeaux).

- Hyponymy (specialisation): the word ***A*** is a hyponym of word ***B*** if ***A*** expresses some special case of ***B*** (e.g. Medoc is kind of a Bordeaux wine, thus Medoc is a hyponym for Bordeaux, as shown at Fig. 6).

- Holonymy (whole-of relationship): the word ***A*** is a holonym of the word ***B*** if ***A*** includes ***B*** as a part (e.g. the Medoc region is a part of the Bordeaux region, i.e. in this sense Bordeaux is a holonym for Medoc). This example shows that synset relationships may depend on a domain (Bordeaux if considered as a wine and not as a region, could not be understood as the holonym for Medoc).

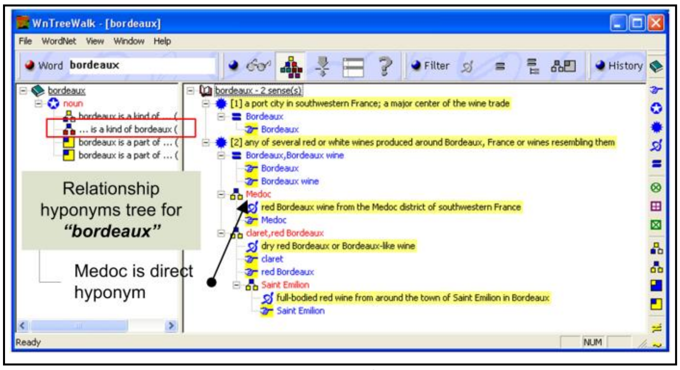

Fig. 6. Hyponymy relationships in a tree form viewed in WnTreeWalk [21]

- Meronymy (part-of relationship): the word ***A*** is a meronym of word ***B*** if ***A*** is a part of ***B*** (see Fig. 7).

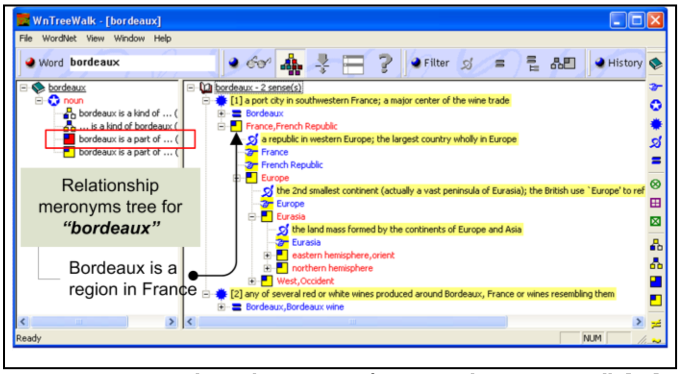

Fig. 7. Meronymy relationships in a tree form viewed in WnTreeWalk [21]

- Sister related words: the word ***A*** and the word ***B*** may be considered as sister terms if ***A*** and ***B*** have some indirect relationships through common hypernyms, hyponyms, holonyms or meronyms (e.g. Medoc and Moulis considered as wines are sister terms, since they have common hypernym "Bordeaux wine").

The idea of using synsets is based on consideration that a user trying to find some information about Bordeaux wine may also be interested in more specialty (e.g. Medoc wine) or more generality (e.g. French wine) in this search, or in some indirectly related domains, such as discovering the region where these wines are being produced.

In addition, exposing such sister terms may prompt new user's ideas about the information the user is trying to find. Probably, the user is searching not exactly (or exactly not!) a thing described by the query. For example, when user inputs the request "Effective use of Google", the hint "Search engine is generalization of Google" (expressed probably in visual form) may lead user to the understanding that he or she wants to learn about a search engine as such, and not about Google's engine in particular.

It should be noted that synsets don't always express relationship properties in the best way. For example, types of part-whole relationships listed below differ semantically from each other:

- Functional relationships between the whole and its parts, e.g. a wheel as a part of a bicycle remains a wheel even after it has been separated from the bicycle (in contrast to a bicycle that doesn't exist without wheels).
- Role playing relationships, e.g. every partner is an integral part of a couple: if one partner leaves, there is no couple anymore.
- Spatial-temporal relationships, e.g. a tree is considered part of a forest, yet if the tree is removed from the forest the tree remains a tree, and the forest remains a forest.
- Meronymy relationship as a result of entity partition, e.g. a piece of pie is also a kind of pie.
- Meronymy relationship expressing the material or composite structure of an object, where it is impossible to detach a part without destroying the whole entity. As Perec expressed in his fabulous novel, "The Life: User's Manual," when the parts of a jigsaw puzzle are pieced together, the pieces simply disappear as separate entities [22].

Specific types of relationships correspond to types of ontology. Despite the fact that usually different ontology types are not to be mixed, in concrete cases such mixing may appear. As an example, WordNet ontology is a combination of several ontology types, such as taxonomy ontology, partonomy ontology, etc.

In spite of some limitations, there are at least two factors supporting the idea of using semantic relationships based on synsets. On the one hand, when we explore the respective fragments on a taxonomy tree we better identify the context in which the terms are used. On the other hand, the relationships we discover then help us to generate hints allowing users to include more general or more specific terms in the query. To achieve reasonable improvement of the query, detailed semantic analysis may not be necessary.

IV. WordNet Based Search Assistant

Typically search assistants are being implemented either as a browser plug-in or as a local web page to be used as a proxy to the search engine (or engines). In comparison to plug-ins, the web page based solution normally has no problems with browser compatibility; however plug-in based solutions may be more functional and convenient from the user's point of view because of its potential for integration with the browser the user likes.

Most search engines are oriented to the usage model, "the query line as input, the list of web pages (or references) as output". Many users believe (which is incorrect) that a query is a sentence written in natural language. In most cases, however, there is special query language syntax that the search engine parser can recognize. Due to the formal query language we can construct more exact queries, but the language syntax is not intuitively clear to all users. Therefore people often do not gain any advantage from using query languages.

A. User Query Modification

The main purpose of query modification is to help users construct good queries that support a better navigational search. According to the general impression of the searching process, query modification is realised iteratively. Usually we change the query if the results do not meet our expectations. The main idea of the concept of cognitive synonyms is to help users control changes that will lead them in the right direction.

Therefore, the query is the subject of two types of modification, semantic modification and modification of the view.

Semantic modification is made by the user by paying attention to the information retrieved from the ontology. The original query terms may then be replaced or complemented by their relatives (hypernyms, hyponyms, holonyms, meronyms, etc.).

The query view may be modified automatically before passing the query to the search engine. This type of modification is based on the idea that search engines are able to process relatively complex queries (in comparison to those users normally construct) including such operations as OR, AND, NOT, etc. Many users do not always use such expressions since they are not natural for them.

B. Representing the Query in the Form of a Token Network

The first task of a search assistant is to provide a more flexible interface in comparison to the traditional query edit box in regards to better usage of the search engine's features.

Our approach is to visualise the query in the form of a token network. Most query languages contain "AND" and "OR" operators in the query syntax, so we can use a visual interpretation of these operators as shown in Fig. 8. The implementation issues are discussed in detail in section IV(D).

The graph may include two types of nodes: AND-nodes and OR-nodes. The graph is transformed to the textual search query by using respective query language operators as shown in Fig. 8.

The type of network presented in Fig. 8 is adequate for most European languages. For languages based on other written text representation (e.g. Arabic, Chinese, Japanese, Korean, Hindi, etc.) this query network structure has to be the subject of separate research.

C. *Interactive Query Modification*

The next task of a search assistant is to help users create queries that better express their needs. The system provides hints generated with information retrieved from the WordNet dictionaries (in our implementation we used the WordNet ontology for the English language). This allows the user to improve queries, step-by-step, in an interactive way. We have implemented the following types of query modification:

- Use of dictionary terms to replace the selected query term (with the help of a special toolbar shown in Fig. 8).
- Adding a new word to the query (to create a new node in the visual query graph).
- Removal of words (remove the corresponding node).

D. *The Implementation*

The search assistant is implemented as an HTML page consisting of two frames. The first (upper) frame contains a JavaFX applet providing two main features: assisting the user in the process of creating a (better) query; constructing the textual query for the search engine (e.g. Google in our work). The second (lower) frame is used to show the results obtained from the search engine.

This HTML based implementation is browser independent (which is guaranteed by the HTML specification), operating environment independent (because of using a Java virtual machine), as well as deployment independent (the applet may be deployed locally or by a remote server by using the JNLP protocol).

As mentioned earlier, we visualise the search query in the form of a token network, combining AND-nodes (Fig. 8a) and OR-nodes (Fig. 8b). One is able to insert the new nodes by both typing on the keyboard and clicking the mouse. With the keyboard, the spacebar is used to insert a new node to the right of the active node. With the mouse, a special interface control is used to insert a node, to add an OR-branch (Fig. 8c) or an AND-node to the left or right of the active node (Fig. 8d). These controls appear automatically for the active (focussed) graph node.

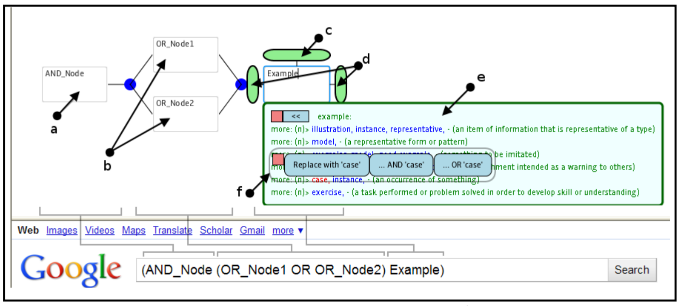

Fig. 8. Search assistant user interface

When one clicks the right button of the mouse or clears the whole text, the node is removed. All the user controls mentioned above are used to modify the query view, not the sense of the query.

To implement semantic modification of the query, we designed a sense navigator. The sense navigator is a kind of interactive pad, dealing with different senses of the query term (Fig. 8e). This selector accesses the WordNet dictionaries to retrieve terms that may be used to modify the query by paying attention to the query term semantics. The sense selector is composed of two parts: the header area and the sense selection area. The header area features some additional controls placed next to the word label (Fig. 8e) including a close button (to close the sense navigator pad) and a back button (to go to the previous state of the navigation pad).

The selection area contains a description of the explored term, where the lines correspond to the different senses of the term found in the WordNet dictionaries. Each line consists of the following elements:

- **More (<word-class>)**: an interactive element to load dictionary terms related to the query term in the concrete sense (e.g. hypernyms, hyponyms, holonyms, etc. for nouns, or hypernyms, troponyms, entailments, etc. for verbs, and so on).
- List of synonyms for the query term (in this specific sense). This element is also interactive. By left clicking the mouse, the viewed term is being replaced by the chosen synonym; the sense description of the new word is loaded into the sense selection area. By right clicking the mouse, the popup toolbar appears (see Fig. 8f). The popup menu features the query graph transformation either by replacing the query term with the selected related term, or by adding a new OR- or AND-node.
- Sense description contains the explanation retrieved from the WordNet dictionary. This element is not interactive.

As soon as the user has completed constructing the query, the token network is transformed to a regular text query and passes the request composed to the search engine.

The purpose of the sense navigator is mainly to achieve a more objective estimation of the query quality, not for the acceleration of query construction. Users may be unsatisfied with the search results for the reason that the first lines produced by the search engine may refer to pages which contain all the query terms but with the wrong sense. Such analysis may force the user to either replace a term with a better one, or eliminate it from the query so it will not affect the procedure of relevance evaluation in the search engine (as it is shown in the following section where we describe an example of a search process).

In a general way, it is not clear what kind of semantic analysis search engines carry out. It means that resources containing synonyms of the term (instead of the term itself) may be discarded as non-relevant data. From the perspective of human centric computing, expanding the query and refining the query semantics with active user participation (not completely automatically) may improve the searching process.

E. *Using the Search Assistant: the Example*

Let us follow an example of a search process. While conducting a search in the field of music, we needed to know some details about the correct Latin letter notation of writing music notes [23]. We did not know (and probably many other people do not know either) that musicians use the term "*pitch notation*" to designate the alphabetical music notation which exists in several forms (such as the Helmholz notation, scientific notation, midi notation, etc.). So we started with the query "letter music system" or "letter music notation" (see Fig. 9).

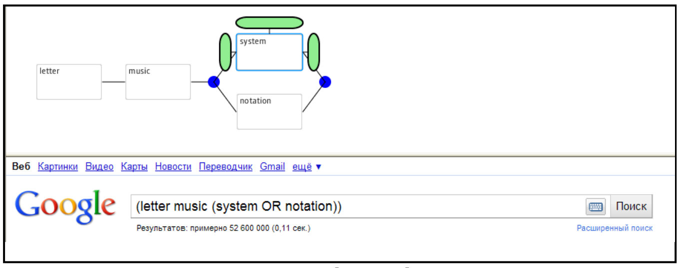

Fig. 9. Example: initial query

After transferring our input to the Google search engine we received a list of page snippets. Since they seemed to be too far away from what we wanted, we analysed the sense of the word "music" with the WordNet dictionaries (see Fig. 10).

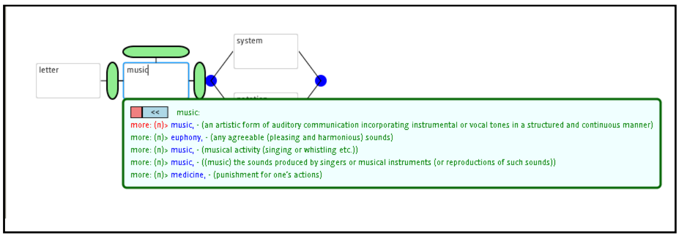

Fig. 10. Discovering active term senses

After choosing the first sense we obtained a list of associations. We selected the term "tune" because the definition we got from WordNet ("the succession of notes") concerned the topic we required (remember that we were searching for the right way to notate a melody fragment in letters). So we discarded the term "music" because it seemed to be too general in our case. Then we replaced the term "music" by the term "tune" with the help of respective buttons in the popup toolbar of the sense selector of the search assistant (as shown in Fig. 11).

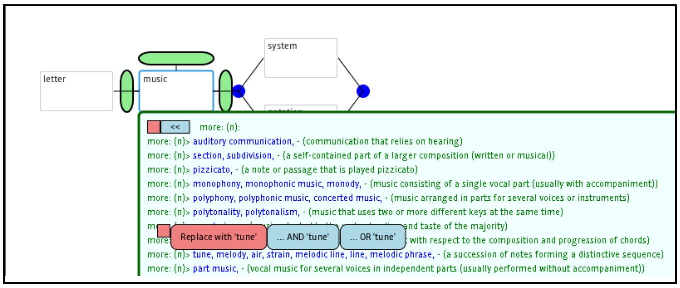

Fig. 11. Replacing the term

From the Google results (as you can see in Fig. 12) we discovered that we were on the right path, but the first links provided us with only trivial examples of musical ABC notation. So we continued to refine the query and examined the list of possible senses (i.e. cognitive synonyms) of the term "tune". There is the sense defined as "the property of accurately producing a note of a given pitch" (Fig. 13).

By clicking the hint "more:" we discovered the synonym for the term "tune" with the above mentioned sense, namely the term "pitch" (see Fig. 14). We again modified the query. The final graph (together with first three links returned by Google) is worth being displayed completely (see Fig. 15).

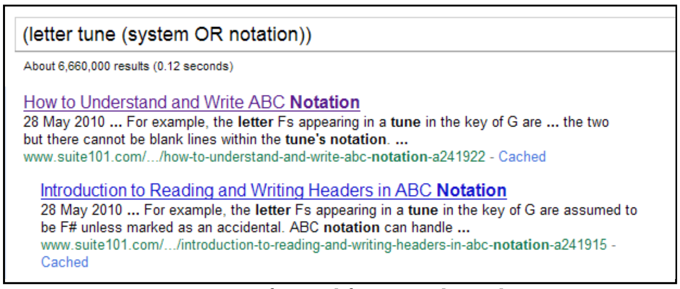

Fig. 12. Text query after modification and Google snippets

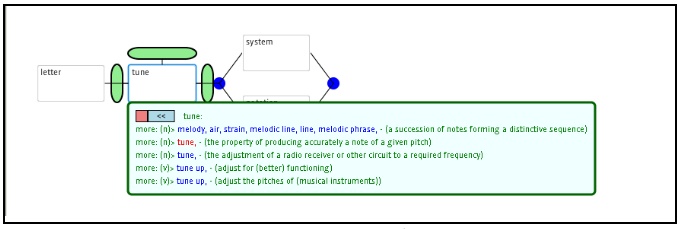

Fig. 13. Exploring the senses of the term "tune"

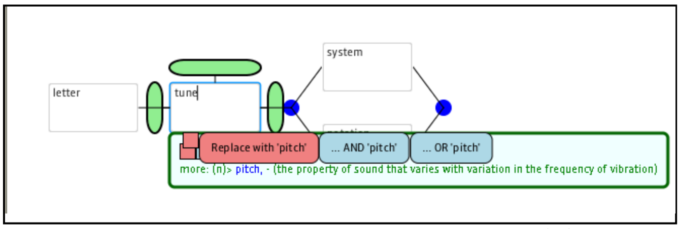

Fig. 14. The term "tune" is replaced with the term "pitch"

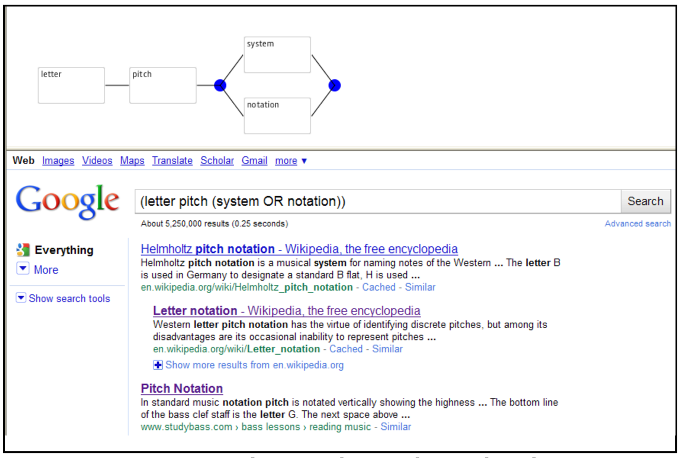

Fig. 15. Final query: achieving the search goal

After opening the respective web pages, we realised that the first two pages contained the comprehensive explanations of the alphabetic musical notation we needed.

An analysis of users' subjective experience of the web search shows that only the first few results are typically looked at by users, pages beyond the first 10-20 links are rarely opened [24]. Thus, it is valuable that the results we obtained from the Google search engine are at the top of the list.

V. CONCLUSIONS AND FURTHER WORK

Despite the fact that the idea of using WordNet as a type of ontology for query expansion has been known for a long time, the novelty of the proposed approach is in the implementation of a visual user interface. This not only displays the relationships between query terms and dictionary terms, but is also a tool that forces the user to change their initial intentions and obtain a query which leads the searcher to better results.

Till now we have only tested the interface in a limited academic environment to be sure of a good display of discovered senses and synonyms and for correct interoperating with the search engine. So, the next step is to find out whether or not users are more satisfied with using such an interactive search interface.

In addition to the user's subjective vision, it is equally important to obtain some objective information about the search process. While monitoring the activity of users whilst searching, we are able to collect some characteristics of the search process itself. The goal is then to estimate how valuable search assisting tools are for concrete users. Being a problem in the field of data mining and knowledge management, there are at least three related tasks in this domain:

- To define the kind of characteristics that should or might be collected (e.g. query length, number of viewed documents, number of relevant documents, search time, number of clicked links, etc.).
- To analyze the search process for both "regular" cases (when the search goal is reached relatively quickly) and "difficult" ones.
- To construct some metrics based on the collected characteristics of the search process.

Finally we should note that most current search problems are shaped by the rapid evolution of the internet grown from the closed research environment used by IT professionals to the global storage of information. There are a lot of different types of resources available, including electronic documents, books, images, music and videos. Regular search engines are mostly oriented to keyword based search processes. Users face essential difficulties when searching for any sort of multimedia resources that do not contain much text. Furthermore, binary multimedia data formats do not correspond well with human abstract intelligence.

Since text based web pages did appear on the internet much earlier than multimedia-oriented services, text based search tools are now more advanced in comparison with special search engines oriented to other types of data. The base of indexed multimedia resources is still rather small. Search criteria do not correspond well with the user's ability to describe the object being searched for. Therefore it is still challenging to find some music or video resources on the web without having exact information about the title, authorship, performer, etc. As a result, users often prefer to ask other people in internet forums instead of using special search services. Thus, research and development aimed at multimedia-oriented web searching tools and interfaces deserve special attention in this area.

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