PLATFORM FOR ELABORATION OF SEARCH RESULTS

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Abstract: We introduce a system called VisElabor that is a platform for elaborating search results. It is a local meta search engine utilizing general search engines. The system downloads a number of documents from the search results and is dynamically able to cluster them and show them on multiple views. VisElabor visualizes relations of documents based on clustering, and it coordinates the information among the views based on user actions in order to better maintain the user context. In addition, VisElabor has been designed so that it is fairly easy to integrate new visualizations and other elaborations into the system.

1 INTRODUCTION

The growth of the Internet has turned Internet search engines into an essential part of the net infrastructure. Popularity has created competition and search engines have evolved immensely. However, the general user interface of search engines has stayed almost untouched for a decade. Users enter some keywords and get in return a linear list of links. Typically, all the computation is done on the server side without utilizing growing computing resources of user workstations.

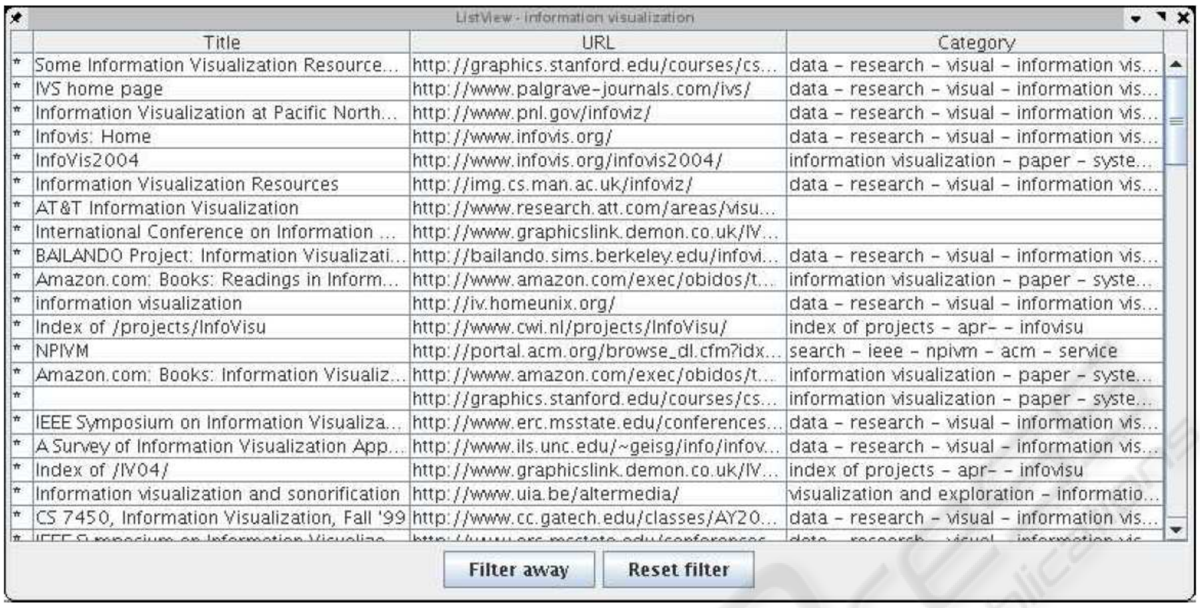
On the other hand, even though the details of the user interface of a single search engine slowly evolve, there is still room for more sophisticated client side tools. This is due to the fact that the search results can be fine tuned if several search engines are used simultaneously. This principle is applied in meta search engines. Our aim is to provide advanced client side software for such search engines in order to enhance the information retrieval process.

In this paper, we introduce a system called VisElabor, which is running on the client machine and is able to dynamically cluster search results and to show several views on them. The idea of VisElabor is to forward a search request to some general search engine and download around one hundred full documents from the search results. The further actions are based on these downloaded documents. The search process is enhanced by showing the search results in multiple views that are coordinated by the system. The user can interact with any of the views. The corresponding data in other views are updated accordingly, and the changes are highlighted in order to maintain the context. At any moment, the user may send a refined search request. Thus VisElabor offers many ways to explore the Web. VisElabor has been designed so that it is fairly easy to integrate new visualizations and elaborations into the system. So VisElabor can serve as a platform for testing elaborations on search results. VisElabor was implemented in Java, and it is freely available under the GPL license[1].

SnakeT (snaket.com) (Ferragina and Gulli, 2005) is a well-known open source meta search engine. There are, however, differences between SnakeT and VisElabor. SnakeT is a large system with a sophisticated clustering algorithm, whereas VisElabor is a light system for playing with visualizations. In addition, VisElabor runs on the client side whereas SnakeT is merely server side software.

In the next chapter, we are going to outline the methods how the search results are visualized in general. Chapter 3 outlines our approach to clustering. The implementation of VisElabor is described in

[1]http://www.cs.hut.fi/Research/SVG/VisElabor/



	Title	URL	Category
*	Some Information Visualization Resource...	http://graphics.stanford.edu/courses/cs...	data – research – visual – information vis...
*	IVS home page	http://www.palgrave-journals.com/ivs/	data – research – visual – information vis...
*	Information Visualization at Pacific North...	http://www.pnl.gov/infoviz/	data – research – visual – information vis...
*	Infovis: Home	http://www.infovis.org/	data – research – visual – information vis...
*	InfoVis2004	http://www.infovis.org/infovis2004/	information visualization – paper – syste...
*	Information Visualization Resources	http://img.cs.man.ac.uk/infoviz/	data – research – visual – information vis...
*	AT&T Information Visualization	http://www.research.att.com/areas/visu...	
*	International Conference on Information ...	http://www.graphicslink.demon.co.uk/IV...	
*	BAILANDO Project: Information Visualizati...	http://bailando.sims.berkeley.edu/infovi...	data – research – visual – information vis...
*	Amazon.com: Books: Readings in Inform...	http://www.amazon.com/exec/obidos/t...	information visualization – paper – syste...
*	information visualization	http://iv.homeunix.org/	data – research – visual – information vis...
*	Index of /projects/InfoVisu	http://www.cwi.nl/projects/InfoVisu/	index of projects – apr– – infovisu
*	NPIVM	http://portal.acm.org/browse_dl.cfm?idx...	search – ieee – npivm – acm – service
*	Amazon.com: Books: Information Visualiz...	http://www.amazon.com/exec/obidos/t...	information visualization – paper – syste...
*		http://graphics.stanford.edu/courses/cs...	information visualization – paper – syste...
*	IEEE Symposium on Information Visualiza...	http://www.erc.msstate.edu/conferences...	data – research – visual – information vis...
*	A Survey of Information Visualization App...	http://www.ils.unc.edu/~geisg/info/infov...	data – research – visual – information vis...
*	Index of /IV04/	http://www.graphicslink.demon.co.uk/IV...	index of projects – apr– – infovisu
*	Information visualization and sonorification	http://www.uia.be/altermedia/	visualization and exploration – informatio...
*	CS 7450, Information Visualization, Fall '99	http://www.cc.gatech.edu/classes/AY20...	data – research – visual – information vis...

Figure 1: The **List View.** shows the title, URL, and category of each document matching the query. The list is sorted in order of ranking given by the search engine applied. By double-clicking an item in the list, the corresponding document is opened into the Full Text View. It is also highlighted in the Graph View. In addition, the buttons in the bottom of the window can filter documents out of the search results. Asterisk (*) at the front of line denotes that the full text retrieval is completed. This view is intended to be used in tandem with the Category View.

Chapter 4, and a use case example is given in Chapter 5. Finally, the significance of the VisElabor is discussed and ideas on further development are presented in Chapter 6.

2 VISUALIZATION OF SEARCH RESULTS

Visualization promotes understanding of information. We consider how visualization can enhance Internet searches.

A typical Internet search has four phases.

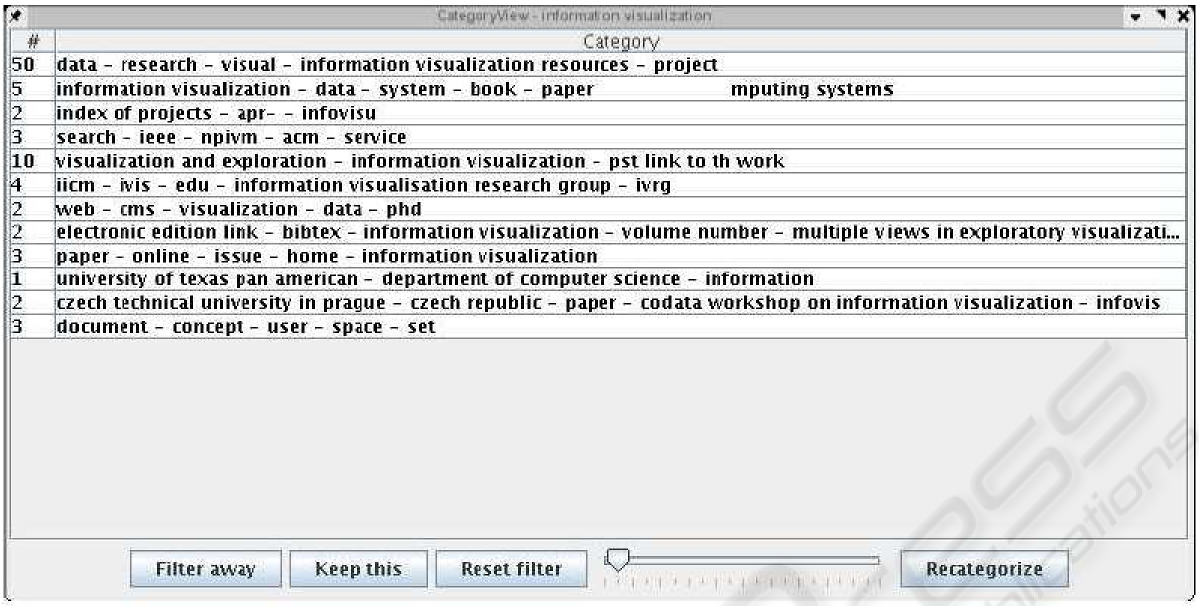
1. Formulate the search conditions.
2. Launch the search.
3. Review of results.
4. Refine the search conditions.

The phases are closely connected with phases of creative problem solving (Sutinen and Tarhio, 2001). Like problem solving, Internet search is a cyclic process, where phase 4 is followed by phase 2. There are visualization techniques for each phase. In this paper we concentrate on phase 3.

Most techniques visualize relations of a set of documents usually based on clustering. Typically a set is visualized as a graph (Mann, 1999) or as a map (Kohonen et al., 2000), where representations of related documents are connected by an edge or are situated close to each other. Another type of views is associated with relevance numbers. One visualization of this kind is shown at Thumbshots (ranking.thumbshots.com), which illustrates the difference in relevance in two searches on related topics or with different search engines. There are also techniques to visualize aspects of a single document. Tilebars (Hearst, 1995) and relevance curves (Mann, 1999) show approximate locations of search keywords within a document.

Typically there are only few alternatives to sort textual lists that current search engines provide. The Kartoo (kartoo.com) and the Mooter (mooter.com) meta search engines are currently the only search engines that offer visualization. The visualization of Mooter is a simple star-like graph of unnested clusters, whereas Kartoo shows the search results as a more sophisticated map. Also VisElabor shows search results as graph based on the TouchGraph (TouchGraph, 2005) library. A few years ago, Alta Vista (altavista.com) had a service showing the search results as a concept map, but this service has been discontinued.

Exalead (www.exalead.com) shows thumbnail



#	Category
50	data - research - visual - information visualization resources - project
5	information visualization - data - system - book - paper mputing systems
2	index of projects - apr- - infovisu
3	search - ieee - npivm - acm - service
10	visualization and exploration - information visualization - pst link to th work
4	iicm - ivis - edu - information visualisation research group - ivrg
2	web - cms - visualization - data - phd
2	electronic edition link - bibtex - information visualization - volume number - multiple views in exploratory visualizati...
3	paper - online - issue - home - information visualization
1	university of texas pan american - department of computer science - information
2	czech technical university in prague - czech republic - paper - codata workshop on information visualization - infovis
3	document - concept - user - space - set

Figure 2: The **Category view.** shows the names of the categories and the number of documents within a category. The threshold value described in the previous section to control the creation of new clusters can be changed with the slider bar at the bottom of the window. The clustering adapts to these changes dynamically or the clustering can be restarted with the Recategorize button. By double-clicking an item in the list, the corresponding documents within this category are shown in the List View. In addition, the buttons in the bottom of the window can filter whole categories out of the search results.

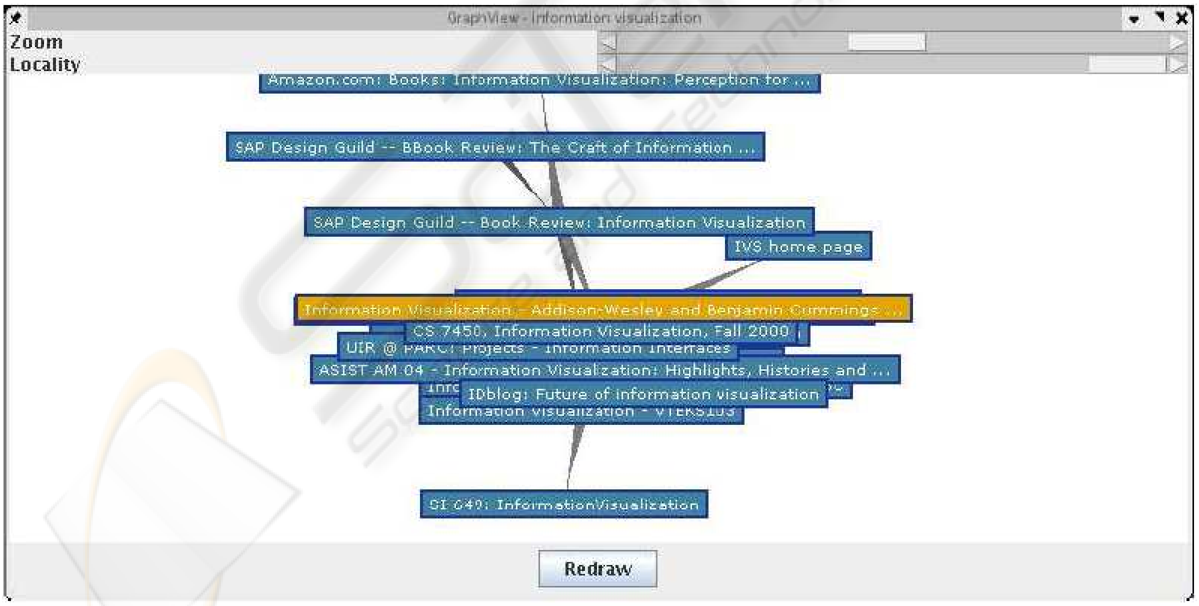
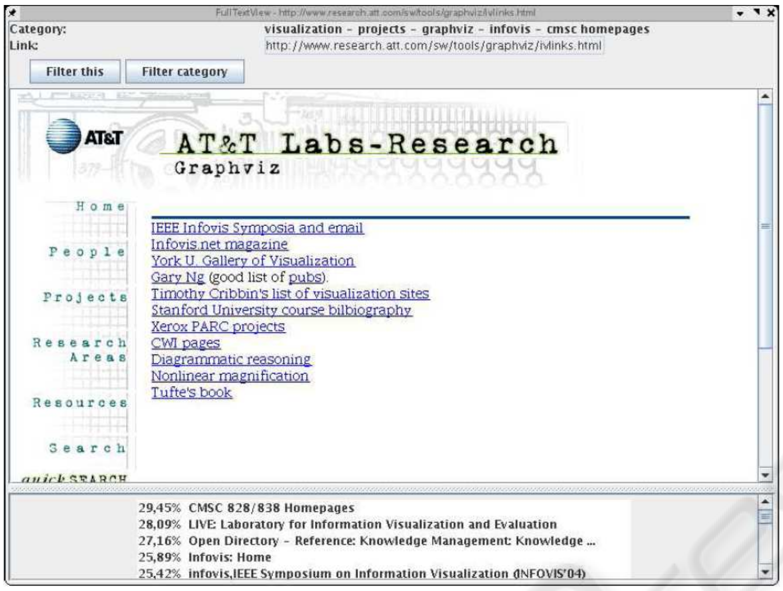

GraphView - Information visualization
Zoom
Locality
Amazon.com: Books: Information Visualization: Perception for ...
SAP Design Guild -- BBook Review: The Craft of Information ...
SAP Design Guild -- Book Review: Information Visualization
IVS home page
Information Visualization - Addison-Wesley and Benjamin Cummings ...
CS 7450, Information Visualization, Fall 2000
UIR @ PARC: Projects - Information Interfaces
ASIST AM 04 - Information Visualization: Highlights, Histories and ...
IDblog: Future of information visualization
Information Visualization - VTEKS103
SI 649: InformationVisualization
Redraw

Figure 3: The **Graph View.** represents the relationships among search results. Each node represents a single search result. Similar nodes are connected with edges: the more alike two search results are the shorter and thicker the edge between them. The size of the graph can be adjusted with the Locality slide bar, which sets the maximum path length from the selected node. The view can be zoomed, and explored freely. Selected items are also highlighted in the List View. By double-clicking a node, the corresponding result is opened in the Full Text View as well. In addition, the right mouse button allows to filter single documents out of the view. The view was implemented by reusing the TouchGraph library (TouchGraph, 2005).



Category: visualization - projects - graphviz - infovis - cmsc homepages
Link: http://www.research.att.com/sw/tools/graphviz/ivlinks.html

IEEE Infovis Symposia and email
Infovis.net magazine
York U. Gallery of Visualization
Gary Ng (good list of pubs).
Timothy Cribbin's list of visualization sites
Stanford University course bilbiography
Xerox PARC projects
CWI pages
Diagrammatic reasoning
Nonlinear magnification
Tufte's book

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29,45%  CMSC 828/838 Homepages
28,09%  LIVE: Laboratory for Information Visualization and Evaluation
27,16%  Open Directory - Reference: Knowledge Management: Knowledge ...
25,89%  Infovis: Home
25,42%  infovis,IEEE Symposium on Information Visualization (INFOVIS'04)
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Figure 4: The **Full Text View.** shows the search results in a simple browser window. In the top of the window, there is an address field. In addition, the current category is shown above that. A speciality is the list of similar documents in the bottom of the window that is updated dynamically as new search results are clustered. By double-clicking a document in the list, it is opened in the Full Text View as well as highlighted in the Graph View. Moreover, search results and categories can be filtered out with buttons similar to that in the other views.

pictures of found pages. This feature, which used to work also with MSN search (www.msn.com) helps the user to quickly pick up the right page, especially when he misses the right URL for a page seen earlier. Clusty (clusty.com) provides categories and a quick preview of a page. Google (google.com) provided a service called Google Viewer which displayed search results as a continuous slide show. This service has been discontinued. Currently VisElabor does not have any of these quick views, but it would be possible to adopt some of them.

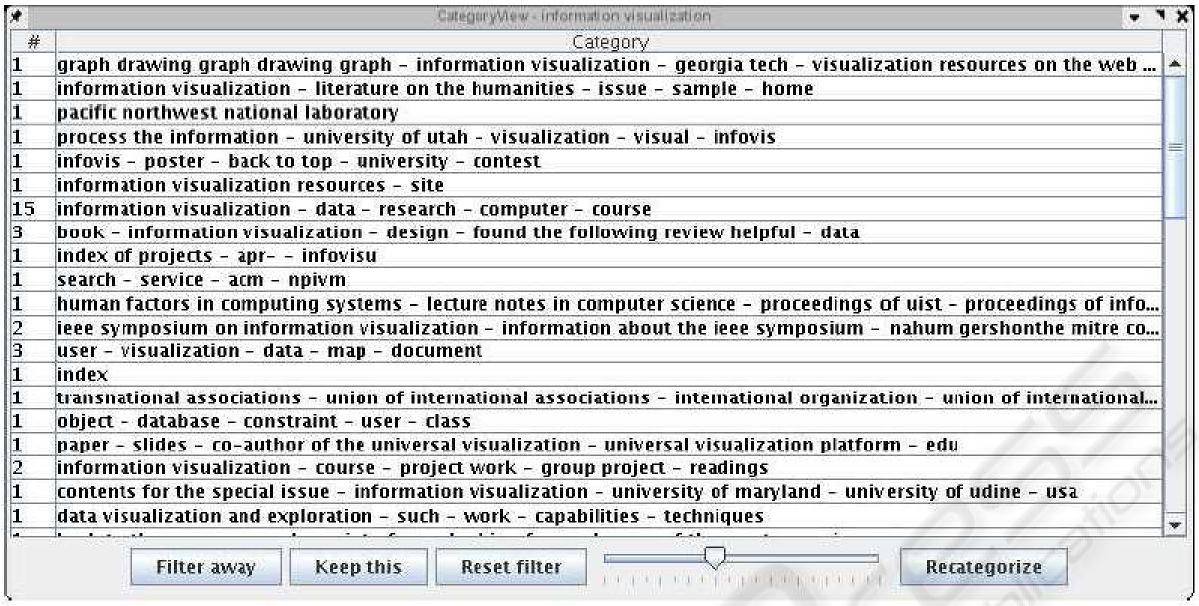
Google is able to give pages similar to the current page. TouchGraph (TouchGraph, 2005) uses this characteristic and shows the results as a dynamic graph. The user can extend the graph by selecting another node. TouchGraph is an applet that runs on the user machine.

3 CLUSTERING

Clustering of search results is not per se associated with visualization, but it is necessary in order to visualize categories. Algorithms that apply predefined categories are complicated to implement and they need training. For VisElabor we selected straightforward dynamic clustering, which was suitable for our needs. Our algorithm uses the scalar product based on word chains. This is a fairly common technique applied in many other clustering algorithms (Klose et al., 2000). The closer to one the scalar product is the more identical word chains two documents have.

A session starts with submitting a query to a general purpose search engine. Currently we use Google, but it is easy to modify the system to use other engine or any combination of them. The 100 first documents of the result are then downloaded. The phases of the algorithm are the following.

1. Download the full text of the selected documents. Remove html tags and other parts of the documents that are not connected with the contents.
2. Divide each document to sentences according to punctuation marks. From the sentences, form all possible consecutive chains of at most five words. Eliminate all chains ending or starting with a stop word. Store the remaining chains into a chain vector of each document.
3. Eliminate those chains which appear only once in the chain vector.
4. Compute the scalar product of the chain vector with the vector of each other document.
5. Based on the scalar product, associate the document with the cluster containing the closest doc-



#	Category
1	graph drawing graph drawing graph – information visualization – georgia tech – visualization resources on the web ...
1	information visualization – literature on the humanities – issue – sample – home
1	pacific northwest national laboratory
1	process the information – university of utah – visualization – visual – infovis
1	infovis – poster – back to top – university – contest
1	information visualization resources – site
15	information visualization – data – research – computer – course
3	book – information visualization – design – found the following review helpful – data
1	index of projects – apr- – infovisu
1	search – service – acm – npivm
1	human factors in computing systems – lecture notes in computer science – proceedings of uist – proceedings of info...
2	ieee symposium on information visualization – information about the ieee symposium – nahum gershonthe mitre co...
3	user – visualization – data – map – document
1	index
1	transnational associations – union of international associations – intemational organization – union of international...
1	object – database – constraint – user – class
1	paper – slides – co-author of the universal visualization – universal visualization platform – edu
2	information visualization – course – project work – group project – readings
1	contents for the special issue – information visualization – university of maryland – university of udine – usa
1	data visualization and exploration – such – work – capabilities – techniques

Figure 5: Category View with 40% threshold value.

ument to it. If there is no document closer than a threshold value, form a new cluster for this document.

6. Form the name of a category from the most common word chains of the category.

Each word chain has a fixed position in the chain vector, which is a vector of scores. The score is $1.5*w*c$, where w is the width of the chain and c is the count of words. We implemented chain vectors as hash tables.

The user controls the creation of new clusters by changing the threshold value. The name of a category adapts dynamically to the changes in the category.

Straight-forwardness and easy interaction are the strengths of our algorithm. It is fast enough for online use, and it works iteratively. The produced clusters or categories are not always relevant, or their names may be misleading. The current solution produces clustering of one level. This is sufficient for one hundred documents used in the tests. For larger sets of documents, clustering should be hierarchical.

In our tests, the elimination of word chains appearing once and allowing chains of up to five words were essential features in improving the quality of clustering.

4 FOUR VIEWS

One way to improve the search process is to utilize multiple views that can ease the search process (Baldonado, Woodruff, and Kuchinsky, 2000). Separate views, however, need to be interconnected to each other in such a way that the user can realize how the information in one view relates to another. Several techniques exist to achieve this, but the main principle is that the user should be able to link the information in all of the views to a single document. Typically this linking is perceived by selecting a document within one view, and the corresponding information is highlighted also in the rest of the views.

VisElabor displays the search results in four windows and coordinates the information among the views based on user actions. In Figures 1 to 4, there are snapshots of a query and the resulting windows:

1. List View (Figure 1)—ordered list of hits based on the search engine ranking
2. Category View (Figure 2)—ordered list of categories (clusters) based on cluster size
3. Graph View (Figure 3)—graphical overview of the documents and their relations
4. Full Text View (Figure 4)—the selected document in a browser window

5 USE CASE

In addition to the different views described above, the prototype application has a separate main window in which the query is entered (the figure of this is omitted due to brevity). One can enter a new query, or double click an old one to make the search again. As soon as the query is entered and the search engine(s) respond(s), the result lines and nodes start appearing into the List View and Graph View, respectively. An asterisk at the beginning of a result line indicates that also the full text has been retrieved.

Meanwhile, the clustering algorithm creates new categories that start to appear into the Category View. In the early phase, the number of categories and their names vary heavily while new full texts are retrieved. If the task is to have an overview, some 5% threshold would be the most feasible as in Figure 2. Thus, fewer categories are created and it is easy to filter out unnecessary results.

By double clicking a category, the List View shows the corresponding results. Due to the low threshold value, not all category names are related to the results. In addition, some categories consist of empty pages that can be filtered out. After this, the threshold can be raised (e.g., to 40% as in Figure 5) in order to focus on single documents. For example, in order to pick up new expressions that better match to the query. By lowering and raising the threshold, it is quite feasible to refine the query and finally pick up only those documents best matching to the certain topic of interest.

The Graph View gives additional information about the documents. Basically, it illustrates how the documents are related to each other. In Figure 3, for example, course home pages and text books seem to have a strong relationship.

6 DISCUSSION

We have demonstrated a way to visualize search results queried from standard Internet search engines. The implemented system VisElabor dynamically clusters search results and shows the information in several views simultaneously. The idea is to coordinate the information among the views based on user actions in such a way that the refinement of the query is easy and straightforward. The aim is to speed up the cyclic search process by providing better ways to cope with the large number of documents typically found in a single query.

VisElabor is running on the client machine. It sends the search request to a search engine and downloads the resulting documents to be clustered dynamically. The results are shown in four separate windows. The List View is fast to compile as it contains only the search results retrieved from the search engine.

The Category View is based on the clustering of the search results. Our clustering algorithm is dynamic, i.e. the user sees the evolving stage of clustering all the time, yet it is possible to interact with the system at any moment. For example, the first cluster is ready to be examined as soon as it appears on the display. The threshold value for new clusters provides the user with a possibility to work on different views on the same data.

The Graph View requires that the system is able to coordinate the information in multiple views and simultaneously regain contextual information in case of real-time updates, i.e., while information constantly flows in from the search engine. The user should be able to follow the changes in order to maintain the context. One way to solve this is to allow updates only by request. The TouchGraph library we use was designed to be applied in real-time applications. In addition, the movements of nodes were animated which is necessary in order to retain the context. Yet, this requires quite a powerful computer.

Finally, a flexible Full Text View requires a browser. Fortunately, a simple browser window can be achieved by utilizing standard libraries. However, in a real application, more sophisticated browser would be required.

The most salient point here is the coordination among the multiple views. Thus, the user can have better overview of the search results, but he can still maintain the context due to the automatic coordination. Even in a dynamic situation in which the search results are constantly updated as they arrive, and while the user itself interacts with the results (e.g., filters out results, or views a single document).

There are several options to apply VisElabor as well as develop it further. First, even though our examples emphasize the client side usage, the system can easily be transformed into a server side version that has a light browser front end. Second, additional visualizations could be implemented so that more users can find a visual interface that appeals them. Third, VisElabor could be enhanced with adaptive personalized information in order to get more relevant search results. This kind of user model consists of preferences given directly by the user and of an adaptive part which is updated after each search request. Maintaining the model locally without sending personal information anywhere else is an obvious advantage. The additional information may be applied to enhancing the search request or to favoring relevant categories in clustering.

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