First publ. in: Proceedings / IEEE Conference on Information Visualisation, July 2003, pp. 600-605

Metadata Visualization with VisMeB

Peter Klein, Frank Müller, Harald Reiterer, Tobias Limbach
University of Konstanz, Department of Computer & Information Science,
Universitätsstr. 10, 78457 Konstanz, Germany
{peter.klein, frank.mueller, harald.reiterer, tobias.limbach}@uni-konstanz.de

Abstract

This paper presents a new framework for Metadata Visualization Systems called VisMeB (Visual Metadata Browser). It is based upon redesign ideas from the INSYDER[1] System that were come under extensive evaluations. The aim of our approach is to improve the process of finding relevant information in an intuitive yet multifunctional way. We use a ScatterPlot in combination with a so called SuperTable for visualization. The two techniques are tightly coupled and present unique possibilities of interaction through the use of visual filters.

1. Introduction

The goals of the research project *VisMeB* (*Visual Metadata Browser*) presented in this paper are to support users in finding relevant data and to enhance the possibilities of browsing and filtering an information space (e.g. digital library, web, geodata base, movie data base). To achieve these goals, our system makes use of different visualizations. Our thesis is, that users will benefit in terms of effectiveness, efficiency and satisfaction[15] from our Visual Metadata Browser compared with common list or table-based presentations. This thesis is not undisputed, as our own work has shown (see [5], where a traditional result list presentation beats the visualizations in usability tests (n=40)). First we assume that users will use our system on a regular basis and therefore a training period for the visualizations will be expected to them. Then based on our experience (see [5]) we have tried to integrate our different visualizations very smoothly in a common tabular visualization. Finally our visualizations cover the whole information retrieval process beginning at the query stage and ending at the relevance feedback.

The main ideas of developing our visual information retrieval system *VisMeB*, using different visualizations and interaction techniques, are presented. *VisMeB* is engineered in the framework of the EC-funded project INVISIP[2]. After this introduction, [Chapter 2] will give a short overview of the system. The query stage with a *Query Preview* [2] will be presented in [Chapter 3]. We will focus on the different visualization and interaction techniques we used, combining the two visualizations *SuperTable* and *ScatterPlot* in [Chapter 4]. [Chapter 5] gives a brief summary of our evaluation studies. The related work that has influenced our own will be presented in [Chapter 6]. Conclusions and outlook are given in [Chapter 7].

[1] Internet Système de Recherche – ESPRIT project #29232
[2] INVISIP – Information Visualization for Site Planning, funded by EC, Project No. IST-2000-29640, www.invisip.de

2. Architecture of VisMeB

VisMeB has a client-server architecture implemented in Java (see Fig. 1). The visual metadata browser can work as an application or an applet within a Web browser. The system provides a dedicated server for storing user-, session- and configuration data (in a postgres database system). So it shares all advantages of a classic terminal application (e.g. stop your work on your laptop and continue with the same session at your workstation in the office).

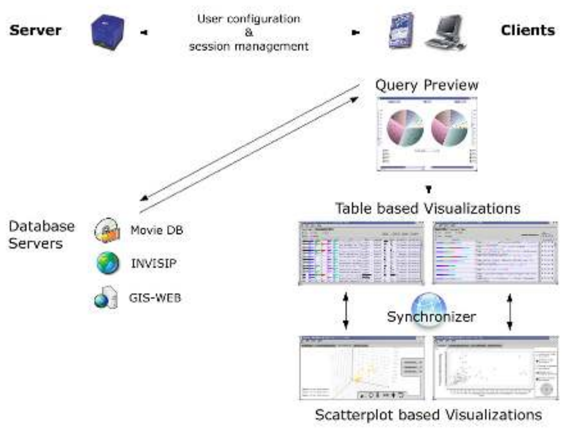

Figure 1: Architecture of VisMeB showing three possible (and available) application domains: A movie database, the INVISIP geodata base and a snapshot of a small part of the WWW concerning GIS (Geo Information Systems).

Especially regarding the site planning process, which is probably not only done in an office but partly in the specific location (e.g. with mobile devices), this part seemed important to us. A visual assistance to formulate the query is given with a domain specific query form with query preview functionality. Access to different metadata bases leads to the display of search results in table and plot based visualizations. Both visualizations have their interactions synchronized.

Keeping the experience with a preceding project called INSYDER in mind, *VisMeB* was kept generic and can be used in various fields of application. The sophisticated data model allows easy adaptation to domain specific needs.

The client consists of the query processor / query preview and our result visualizations. Each visualization is tightly coupled [14] to the other. We implemented a visual configuration editor to easily adopt *VisMeB* to different data sources. This configuration tool is able to access a database with its tables and to map different columns to different visualizations. It can define interactions between visualizations, filter behavior and will be able to adapt to different clients, like PDA, TabletPC or Workstations (we have to accommodate to CPU power, screen size and input devices e.g. we will support gestures for TabletPC).

3. The Circle Segment View

To further improve the smooth change of modalities from the textual input of the query to the visualization of the result set, the idea of Query Previews [2] was adapted. Additionally the users benefit from this because of the prevention of zero-hit or mega-hit queries. The evaluation results [3] for the INVISIP domain show a clear tendency towards filtering out irrelevant data based on some metadata attributes as early as possible.

We introduced a visualization called *Circle Segment View (CSV)*, which emphasizes the distribution of the data. This visualization also gives continuous feedback about the size of the result set.

The effectiveness of control depends on the data type and on the cardinality of the values. So it should be carefully considered which data from our databases matches the requirements of the query preview.

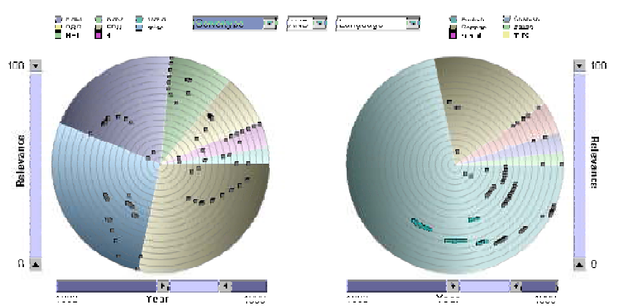

Figure 2: Circle Segment View connected to our WWW database, showing the filter criteria: Server-type, language, relevance and year

The *CSV* (see Fig. 2) consists primary of two circles (pie charts). The whole circle represents the information space. The different segments show the distribution of the data concerning one type of metadata. For each circle the user through drop down menus can choose this attribute. The size of each segment hints at the distribution of the data. A legend on top provides an overview of the different categories. Dots on the circle represent documents. This works up to a few thousand documents. For more documents the dots will vanish until the user has filtered out some of them. The dots are placed using two other numeric metadata. One metadata is mapped on the radius (e.g. relevance) and another one on the angle (e.g. release date). The metadata mapped on the angle is supported by a color gradient to gain easy access to that information (e.g. the older documents lay in the brighter drawn area). To influence this visualization and filter out some documents we use two *AlphaSliders* [4]. The first one specifies a range for the radius (e.g. relevance from 50..100), the second a range for the angle (e.g. a range from 1982 – 2002 is mapped to 10 degrees). By clicking on the *AlphaSliders* a popup window appears and lets us change the assignment for the radius or the angle.

Users have the possibility to link both circles through Boolean expression chosen in a dropdown menu. They can select the documents of a segment by simply clicking on it. The dots will change their colors for feedback and the size of the result set will be altered.

A typical scenario for a search in a movie database would look like this: The user wants to see a new science fiction movie with a good ranking and German language. He chooses 'Genre' for the category of the first circle and 'Language' for the second. After clicking on the segments representing 'German' and 'Science Fiction' he adjusts the sliders to a range of [1995..2002] for 'Release Date' and [70..100] for 'Rank'.

He uses the predefined Boolean 'AND' operator on both circles. The user now adjusts the sliders until the result set reaches an appropriate size. Thereafter he will continue to examine the documents with our *SuperTable*.

The general problems we are facing with this form of query preview are:

- interaction speed <100ms
- tight coupling with our other visualizations
- express Boolean combinations of different queries
- allow varying degrees of intensity in the visual feedback
- add weight criteria to data attributes

4. The SuperTable + ScatterPlot

Two visualizations dominate the global appearance of the result presentation: The *SuperTable* and the *ScatterPlot*. They unify the typically used result list of a search engine like Google with unique combinations of visualizations. The user has the opportunity to obtain a quick overview of the result set as a whole and explores relevant objects step by step. Through brushing and linking we can achieve synchronized visualizations. The *SuperTable* itself consists of a combination of different visualizations. Barcharts, TileBars, and highlighted texts are examples of such.

Two *SuperTable* versions are implemented, a *Level-* and a *GranularityTable*. A browser view to show the documents' content completes the system. A more complete set of used visualizations can be seen in Figure 4, showing the *SuperTable* in the *GranularityTable* version. Note that not the visualization itself is the most innovative thing but rather the kind of usage.

The idea behind those versions is a level concept, which enables the user to change the depth of information he is interested in [5]. The first level offers an overview of all documents; the last level shows the document itself. In between you find different levels increasing their amount of information from the first to the last level (see examples for different levels in Fig. 4). This drill-down functionality is named "*Focus of Interest*".

Figure 3: LevelTable with BarCharts, Relevance Curve, Date and Abstract acting on the same setting as in Figure 4

The first of those design variants is called *LevelTable* (see Fig. 3). Every metadata has its own column, but not all metadata are visible in every level. One special example is the "*Relevance Curve*" (Fig. 3, fourth column from the right). It represents the document as a whole, whereas the length of the visualization reflects the document's length. Important text passages are marked by vertical bars whose height illustrates the factor of importance. This metadata can only be seen in level 3. In return the "Language" or "Document Type" columns (which were visible in the former levels) disappear in this stage. In the *LevelTable*, buttons are used to change levels on the whole document corpus. Pressing a button moves the documents in a body to the corresponding level.

The second design variant named *GranularityTable* (see Fig. 4) differs slightly from the *LevelTable*. Instead of buttons for level altering sliders are used to change from one level to another. The number of levels differs (now you can choose between six). Only four columns are used to show all the information: selection, visualization, text, and granularity. The visualization as well as the text column change their display from level to level, always giving more information than the previous level. In this version it is possible to move single rows to another stage, not only the documents in a body.

The *ScatterPlot* (see Fig. 5) is a two-dimensional coordinate system enhanced by the possibility to allocate the x- and y-axis with every kind of metadata used in the current context. It eases a comparison of document properties, for example document date, size or relevance. Using different colours for the data points adds another dimension that allows a faster perception of important facts.

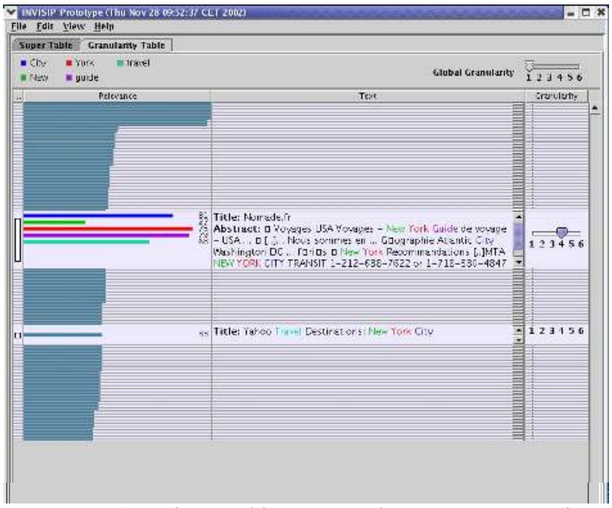

Figure 4: GranularityTable connected to a WWW Database, visualizing the results for the query "New York City travel guide". One Document in level 4 and one with a mouse over magnification

A standard technique to provide additional information of visualizations is the use of tool tips. Moving the mouse over an object shows the characterizing properties. All available information can be retrieved without using the table.

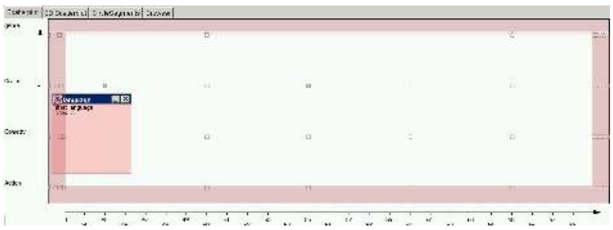

Figure 5: Cutting of the ScatterPlot with MagicLense and a surrounding distortion field

Using a combination of *SuperTable+Scatterplot* enables the user to get a general idea of the entire result set as well as the possibility to explore interesting documents in detail. To reach this goal both visualizations are synchronized, using *brushing and linking*. As a result, for example filtering out objects in the *ScatterPlot* leads to the display of only the corresponding objects in the *SuperTable*, or marking rows in the *SuperTable* marks the respective data points in the *ScatterPlot*.

The *Magic Lens Filter*, influenced by the *moveable filters* by [6], available in the *ScatterPlot*, effects the *SuperTable* as well. Moreover, it is possible to use different lenses simultaneously, which makes it necessary to add half-transparent lens colors. If the lens filters out objects, the background of the corresponding objects in the table changes to the lens color (see Fig. 6). We decided to use this technique to realize the interaction because a permanent movement in the table by removing objects would obviously confuse the user. Moreover, the possibility to explore the filtered documents would be taken away.

Zooming to a cloud of points has the same effect in the *SuperTable* as filtering out points by a global filter: only the zoomed objects are visible in the table.

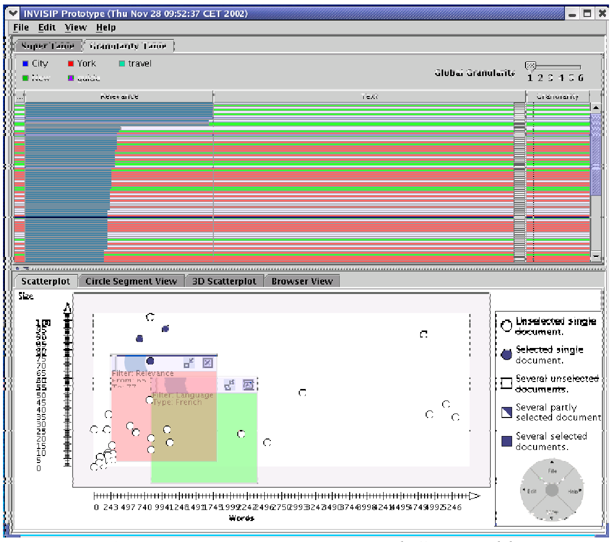

Figure 6: MagicLenses interaction with SuperTable

In this context another technique is used to support the user not to lose the track of things: *focus and context* using distortion. A light reddish frame surrounding the white main area of the *ScatterPlot* represents this context area (see Fig. 5). Zoomed objects stay in the focussed center while remaining points are mapped to the coloured edge. Distortion in x and y direction makes it possible to display all data points in a correct proportion.

Apart from the *2D-ScatterPlot* a *3D-ScatterPlot* was realized (see Fig.7). Here data points are visualized as 3-dimensional cubes. Using a light grid in the background for limitation and better orientation emphasizes the *3D* effect. Labels are set to the grid's edge to reach a better clearness. Free rotation providing an illumination from all directions, a zoom function as well as different selection mechanisms complete the equipment of the *3D-ScatterPlot*. An empirical evaluation is planned to discover the advantages and disadvantages of the *3D* compared to the *2D* version.

Special attention was directed to the problem of data point overlapping in the *ScatterPlot*. Objects frequently own the same metadata of specific characteristics leading to the same position in the drawing area. Therefore we introduced a new glyph, the so called *Multi Data Point* or *MDP* to point this fact out to the user. (Fig. 8) shows the *3D* version, visualized as two interlocked cubes.

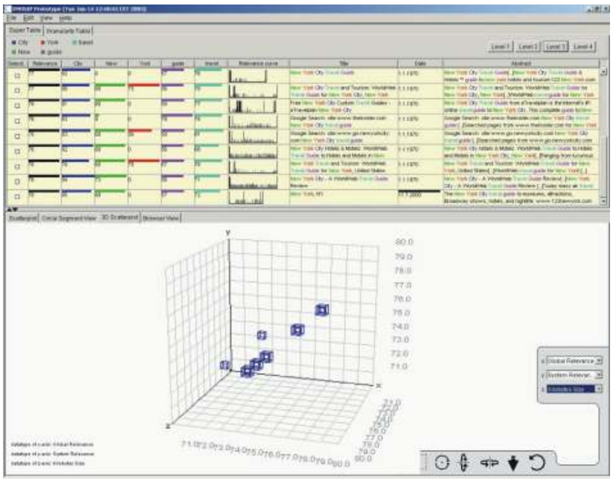
Figure 7: 3D ScatterPlot with LevelTable working with the same setting as in Figure 3, query terms are highlighted in the title and abstract columns.

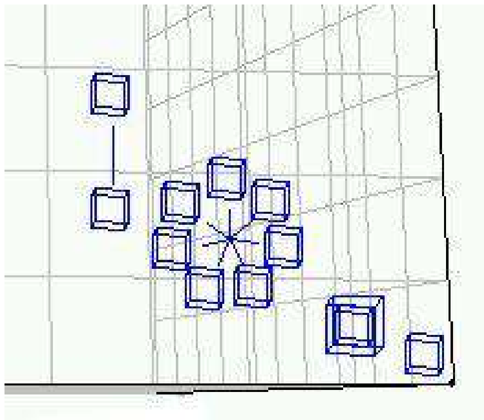
Figure 8: MDP in the 3D-ScatterPlot: In the centre a selected MDP and an unselected one in the lower right corner.

In two dimensions, the circles are replaced by squares that are partially or fully colour filled to indicate if some or all underlying data points are selected. If the user moves the mouse over these *MDPs*, the current glyph disappears and all base data points are positioned on a radial arrangement around the centre (see Fig. 8). Now tool tips are available again for the single data points. Using this technique, overlapping objects can be displayed and analysed separately. One possible problem in this aspect is the high amount of points building such a *MDP*. Too many data points lead to a radius that would burst the available space or to a very small distance between different radial arranged points which makes it impossible to carry out a separate analysis. A possible solution is the use of an animation. The data points circle in an orbital path around the centre of the *MDP* comparable to the *rapid serial visual presentation* [7]. Direction and speed can be varied. Details of the item being actually in the foreground normally shown by tool tips can be seen in a special text area.

5. Evaluation

In the context of the INVISIP project, two formative evaluations (n=8; user tests with expert users from the expected INVISIP target user group and n=31; using an online questionnaire) were made in October 2002 with both *SuperTable* versions, implemented as clickable html-prototypes. Our intention was to compare the different interaction schemes, layouts and visualizations against each other. Overall feedback was very positive, but the limited interaction between *SuperTable* and *ScatterPlot* (partially dependent on using an html-mock-up) was one major criticism, that led us to the interaction techniques described above. The fact that analytic working test users preferred the *LevelTable* version whereas browsing-oriented users more likely chose the *GranularityTable* strengthens us to enhance both variants in future.

5.1 Methodology

After the pre-test questionnaire and a video introduction, the users were handed out a script with test tasks to work on. Minute taking, a video camera and a screen recording documented all tests. This proved to be especially helpful for re-evaluating critical situations of the test, where we could view and analyze the two synchronized videos.

The overall reception of the *SuperTable* + *ScatterPlot* framework was good to very good. Some interactions of the *Level-* and *GranularityTable* were surprising to the users, though appreciated.

In parallel to the lab tests we started a web-based evaluation. Questions regarding individual search behavior, a virtual search with the two design variants, how the users would interact with them and what they would like to have different were asked. The participants were called upon downloading two short introductory videos, and several screenshots correlating to tasks. The sequence of *Level-/GranularityTable* was randomized to exclude learning and last item remembering effects. 35 users completed the questionnaire, which 31 were put into the final evaluation.

Although screenshots are even more limited than the prototypes of the lab evaluation, some results from the former evaluation were confirmed.

5.2 Results

Throughout the test the effectiveness (measured in correct answers regarding interaction) was higher with the *LevelTable* than with the *GranularityTable*. A lack of connection between the table visualizations and the *ScatterPlot* was frequently criticized as well.

An interesting result came from the analysis of search behavior and preferences in design. With five separate questions concerning typical search tasks, we wanted to characterize the users in more analytical or more browsing search strategy types [8]. As could be expected, a mixture between both strategies dominated the sample. Only eight users had very clear preferences, five of them were categorized as "only browsing strategy", three of them as "only analytical strategy". Interestingly enough, four of the first category absolutely preferred the *GranularityTable* and all three of the second category preferred the *LevelTable*.

We assume that at least for the first steps of an iterative search process the *LevelTable* can be efficient to analyze the result set as a whole, maybe find patterns or reformulate/discard the query due to unsatisfactory results. Content is not the primary goal, but filtering and reduction of the result set. If then the results are narrowed down to potentially interesting documents, the *GranularityTable* with its browsing comfort can be used. Now content is the primary goal, modalities can be changed frequently. In this manner, our initially developed scenarios were partly validated by empirical results, though our scenario characters begin the information retrieval process with only analytical, very formal and sophisticatedly formulated queries, while during the iterative retrieval process they become more informal and data driven. Although the evidence should not be weighted too strongly, we took it as a hint to handle both design variants equitable.

Using both tables integrated in one search might speed up and ease the visual information retrieval process. This and further interaction concepts are part of the ongoing redesign of *VisMeB*. A detailed evaluation report is given in [3].

6. Related Work

The visualizations of *VisMeB* have been influenced by many different systems. The *SuperTable* idea, explained in detail in [1], was inspired by multi-focal approaches using focus-plus-context techniques as can be found in a number of tabular data representations. Interactive tables like the *Table Lens* [9] are typical examples. In both systems textual and graphical data representations are used simultaneously. The *TileBars* can be traced back to the work of [10]. The *ScatterPlot* has been influenced by different systems as well. Examples are visual information seeking systems like *Envision* [11] or *xFIND* [12] to name just a few. The *Magic Lens Filter* was influenced by the idea of *moveable filters* by [6]. Synchronisation of *SuperTable* and *ScatterPlot* via brushing and linking was inspired by the work of [13].

7. Conclusions and Outlook

The advantage of the presented system is its smorgasbord of visualizations used to support the user in his search process. New possibilities are given to find the most appropriate data for the current task in an environment where users are accustomed to. The evaluation proved that we are on the right way. A highly sophisticated data model enables us to adapt the system to a wide range of fields like stock market, medical data mining or geo-data infrastructure. The browser view only used to show a single document so far will be extended by a thumbnail view giving the possibility to display and compare more than one document at the same time. *Panning and zooming* is another technique we want to introduce to the *ScatterPlot* to expand its feasibility.

Additionally we prepare the *3D-ScatterPlot* as an alternative for the *2D-ScatterPlot*. We plan to evaluate both systems against each other, focusing on the interaction an efficiency of both.

Work is also in progress in the field of relevance feedback: we plan to implement a visual feedback mechanism, which helps us to find "similar" documents using an animation in both the *ScatterPlot* and the *SuperTable*. The underlying data structures (such as a semantic net) are already in development.

To prove our thesis about the efficient, effective and satisfaction we scheduled a formal usability test for the end of march 2003, where we will have the opportunity to evaluate our system with prospective users of INVISIP.

8. References

[1] Klein, P.; Müller, F.; Reiterer, H.; Eibl, M.:"*Visual Information Retrieval with the SuperTable+Scatterplot*". Proceedings of the 6th International Conference on Information Visualization (IV 02), p. 70-75, IEEE Computer Society 2002

[2] Tanin, E., Plaisant, C., Shneiderman, B. "*Browsing Large Online Data with Query Previews"*. In Proceedings of the Symposium on New Paradigms in Information Visualization and Manipulation (NPIVM) 2000 (Washington D.C., November 2000), ACM Press.

[3] Limbach, T.; Klein, P.; Müller, F.; Reiterer, H.:"*Visualising Metadata: Level- vs. Granularity Concept in the SuperTable / Scatterplot Framework*". To be published in HCI International 2003, 22. – 27.06.03, Crete, Greece.

[4] Ahlberg, C. and Shneiderman, B. "*The Alphaslider: A Compact and Rapid Selector"*. In Proceedings of the CHI '94 Conference (Boston, April 1994), ACM Press, pp. 365-371.

[5] Mann, M. T.: "*Visualization of Search Results from the World Wide Web*", University of Konstanz, 2002, http://www.ub.uni-konstanz.de/kops/volltexte/2002/751/

[6] Fishkin, K.; Stone, Maureen C.: "*Enhanced Dynamic Queries via Movable Filters"*. In: Katz, Irvin R.; Mack, Robert L.; Marks, Linn et al. (Eds.): CHI 1995: Conference Proceedings Human Factors in Computing Systems. Conference: Denver, CO, May 7-11 1995. New York (ACM Press) 1995. p. 23-29.

[7] Spence, Robert "*Information Visualization*". Addison-Wesley 2001 (ACM Press)

[8] Marchionini, G. "*Information seeking in electronic environments*". Cambridge Series on Human-Computer Interaction, Cambridge University Press 1995

[9] Rao, R.; Card, Stuart K.: "*The Table Lens: Merging graphical and symbolic representations in an interactive focus + context visualization for tabular information*". CHI 1994: Conference Proceedings Human Factors in Computing Systems, p. 318-322. New York (ACM Press)

[10] Hearst, M. A.: "*TileBars: Visualization of Term Distribution Information in Full Text Information Access"*. In: Katz, Irvin R.; Mack, Robert L.; Marks, Linn et al. (Eds.): CHI 1995: Conference Proceedings Human Factors in Computing Systems. Conference: Denver, CO, May 7-11 1995. New York (ACM Press) 1995. p. 59-66.

[11] Nowell, Lucy T.; France, Robert K.; Hix, D. et al.:" *Visualizing Search Results: Some Alternatives to Query-Document Similarity"*. In: Frei, Hans-Peter; Harman, Donna K.; Schäuble, Peter et al. (Eds.): SIGIR 1996: Proceedings of the 19th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. Conference: Zürich, Switzerland, August 18 -22 1996. New York (ACM Press) 1996. p. 67-75.

[12] Andrews, K.; Gütl, C.; Moser, J.; Sabol, Vedran; Lackner, W.: "*Search Result Visualization with xFIND" .UIDIS* '01: Proceedings of the Second International Workshop on User Interfaces to Data Intensive Systems, IEEE 2001

[13] North, Christopher L.; Shneiderman, B.: "*Snap-Together Visualizations: Can Users Construct and Operate Coordinated Views*". International Journal of Human-Computer Studies, p. 715-739

[14] Ahlberg, C.; Shneiderman, B.: "*Visual Information Seeking: Tight Coupling of Dynamic Query Filters with Starfield Displays"*. In: Adelson, B.; Dumais, S.; Olson, J. S. (Eds.): CHI 1994: Conference Proceedings Human Factors in Computing Systems. Conference: Boston, MA, April 24-28 1994. New York (ACM Press) 1994. p. 313-317.

[15] ISO 9241-11 ISO 9241-11 "*Ergonomic requirements for office work with visual display terminals (VDTs) – Part 11: Guidance on Usability"*.