Facilitating the Handling of Documents through Tree-Map Visualization

Elis Hernandes[1], Erika Hohn[2], José Carlos Maldonado[2] and Sandra Fabbri[1]
[1]*Software Engineering Research Lab (LaPES), Universidade Federal de São Carlos, São Carlos, Brazil*
[2]*Institute of Mathematics and Computer Science (ICMC), Universidade de São Paulo, São Carlos, Brazil*

Keywords: Tree-Map, Information Visualization Tool, Hyperlink Function, Data Analysis, Structured Reading, Visual Analysis.

Abstract: Applying visualization to manipulate a large volume of data constitutes a current demand of professionals and researchers. Visualization stimulates human perception and increases the understanding capacity. In literature, there are many studies on the use of visualization in different areas, as well as tools that make its use feasible. Aiming to facilitate user's comprehension, the objective of this paper is to explore, in the tree-map visualization, the combined use of the following functions: search, edit, data regrouping and hyperlink. This proposal was derived from two real problems: 1) to standardize a great volume of educational assessment questionnaires that could not be processed automatically; and 2) to analyze the dependencies among the TMMi (Test Maturity Model Integration) process areas, having simultaneous access to the text of all the ones related to a specific issue. The functions were implemented in the SeEd-Visual tool (Search and Edition based on Visualization), and organized in a process that aims to enhance user's comprehension through a visual metaphor. The process and the tool were applied to the real problems and allowed their solution. The use of visualization enabled the solution of the real problems since it would be hard if done manually.

1 INTRODUCTION

Nowadays, visualization has been used for different proposals as scientific data analysis, knowledge discovery, data mining, etc. (Rübel et al., 2010) (Silva et al., 2011). According to Card, Mackinlay and Shneiderman (1999), visualization focuses on mapping data into a visual form, aiming at supporting human interaction usually through a tool for visual sense making.

Burley (2010) emphasizes that information visualization is a valuable tool for knowledge integration activities. This fact has been increasing the visualization application area which is driven by a mix of practical needs and research interest.

In this paper, we show the use of visualization to make easier the solution of two real problems. In both cases, to solve the problem it was needed to handle a large document. In one case the automatic handled of the document was not possible and, in the other one, the manual handle of a big document was infeasible.

Once identified that visualization could simplify the problems solution, the development of SeEd-Visual (Search and Edition based on Visualization) tool was started. This tool uses tree-map visualization combined with the following functions: search, edition, data regrouping, and hyperlink navigation. The use of these functions allows finding a specific data highlighting it in the metaphor; modifying data generating real-time regrouping in the metaphor; and opening external documents associated with a specific data found through the search function. The intervention in the visualization associated to the regroup and hyperlink functions facilitates the comprehension and the analysis of large documents.

The rest of this paper is organized as follows: in Section 2, some researches related to the work presented here; in Section 3, it is explained how the functions search, edit, regroup and hyperlink impact the visualization process and also how the SeEd-Visual tool works. Section 4 presents the two practical needs that motivated the development of the SeEd-Visual tool and how these problems were solved by using this tool; and finally, Section 5 presents the conclusions and further work.

Hernandes E., Hohn E., Maldonado J. and Fabbri S..
Facilitating the Handling of Documents through Tree-Map Visualization.
DOI: 10.5220/0004003300980104
In *Proceedings of the 14th International Conference on Enterprise Information Systems* (ICEIS-2012), pages 98-104
ISBN: 978-989-8565-11-2

2 RELATED WORK

In literature, there are many researches that explore the use of visualization to support the execution of different tasks and to facilitate the resolution of different problems. In this section, some researches undertaken in the context of document handling and of characterizing functions provided by visualization tools are commented.

Deep Diffs (Shannon et al., 2010) is a tool that allows the analysis of document evolution through the view of all the older versions. Parts of the text that have been changed over multiple successive versions are highlighted by the tool, drawing attention to passages that are new, potentially unpolished or contentious. This tool can be applied in a post-hoc way to any text document stored in a version control system integrated into a wiki, a source-code revision system or a content-management system (CMS). Deep Diffs helps the writing and the editing processes by assisting memory and encouraging the analysis of collaboratively-authored documents, through a text editor and viewed by the tool with application of different colors.

Another tool is the ResultMaps (Clarkson et al., 2009) that helps the analysis of digital library lists which are organized through. tree-map visualization. Once the user has applied a query, the result is showed as a list of items, which are highlighted in the tree-map visualization. From this point, in case the user navigates on the result list, data on these items are presented in the visualization. In this case, the interaction between the user and the visualization happens through brushing.

OpinionSeer (Wu, 2010) is a tool developed to facilitate the analysis of customers' opinion on a product or service. These opinions have been collected online, which encourages their post and generates a large volume of data. Aiming at facilitating the analysis, the tool provides a visual presentation of these data through scatterplots and radial visualization.

The family of tools called PEx – Projection Explorer (Paulovich et al., 2007) has been applied to analyze and to verify the relationship among many documents, which makes this error prone task easier. PEx is an example of tool that provides the analysis of different types of textual documents. PEx-Image (Eler, 2009) allows the analysis of an image set and PEx-Web (Paulovich, 2008) allows the analysis of data recovered by web searches. The three tools allow the user to open the visualized documents (image, PDF documents, text and web pages).

The TreeMap tool (HCIL, 2003) implements the tree-map technique (Johnson, Shneiderman, 1991). To promote an increasing knowledge on data, the Treemap allows hierarchies, filters construction and color exchange. However, even though the tool makes different ways of modifying the visualization available, it does not provide search and edit functions.

In summary, visualization tools have given support to different tasks. There are tools that provide different types of visualization and one of their most common characteristics is an appropriated interaction type. Although some of the tools deal with documents – text, images and metadata –, none of them provides functions like search and edit, as proposed in the tool presented here.

3 VISUALIZATION PROCESS

Motivated by the real problem of analyzing and standardizing a large volume of data, a visualization-based process and a the SeEd-Visual tool, that supports this process, have been defined. Other versions of the tool are been used to help the resolution of similar problems.

The first problem that triggered the definition of the process and the initial version of the tool is:

- *The context:* (i) a set of questionnaires that were applied periodically, during twenty years; (ii) each questionnaire was composed of about seventy questions; (iii) each year a questionnaire was applied, the writing of a question previously used was not necessarily the same; besides, new questions could be inserted and old questions could be removed;
- *The problem*: determining which questions were applied in each year;
- *Background:* (i) an automatic comparison could not be applied since the writing of many questions were different and; in addition, a typo could also interfere; (ii) handling the questionnaires by hand was not feasible; (iii) making a decision in case syntactically different questions were semantically equal implies human analysis; (iv) visualizing simultaneously, all questions that could be semantically equal, seemed the best option.

Thus, considering the foregoing explanation, visualization seems to be an alternative to aid the problem solution. As seeing all the questions simultaneously would facilitate the analysis, the tree-map technique (Johnson and Shneiderman, 1991) was defined as the starting point. This algorithm uses one hundred percent of the screen and the color and the size of the boxes are appropriated for large volume of data. Based on this decision, each box would represent a question and the box color would represent the year when the question was applied. In addition, identical questions would determine the grouping of the boxes. The advantage of using treemap instead of list, for example, is the possibility of attributing different representations, like color and size, to distinguish different data.

However, these decisions were not enough. Aiming at solving the problem, it would be necessary to identify questions that were semantically equivalent – then, the need of the search function; and to edit the writing of these questions, aiming at concluding the analysis – then, the need of the edit function. Once any edition is made and the semantic equal questions are changed into syntactically equal questions, this information immediately impacts the visualization by regrouping the questions.

Therefore, the search and the edit functions promote a real time change in the visualization, which facilitates the handling of these data. According to Kan et al (2010), it is important that the user interacts with the visualization, since it makes the information easily understood. In Figure 1 Card's process (Card et al., 1999) was adapted to represent our process.

As shown in Figure 1, the search function impacts only the visual metaphor. In the SeEd-Visual tool, the usage of this function corresponds to the definition of a keyword, which highlights the questions that have that keyword. On the other hand, the edit function impacts the tabular data, which impact the result of the tree-map algorithm application, which, by its turn, generates a new visualization. In the SeEd-Visual, the use of this function corresponds to the selection of a question and to the edition of its writing.

After the definition of this process and the implementation of the corresponding tool version, the following problem was raised:

- *The context*: the need of dealing with a large document – the TMMi reference model. This model is a guide for test process improvement (TMMi Foundation, 2011).
- *The problem:* identifying dependencies among the practices.
- *Background:* (i) as the available document of the TMMi reference model is a PDF file, the search function of PDF readers locates an occurrence of a keyword at a time; (ii) handling the TMMi document manually was not feasible; (iii) making the decision on practices dependencies implies human analysis.; (iv) seeing all the practices that cover the same issue simultaneously seemed the best option to identify dependencies.

By analyzing both problems, it is possible to observe similarities between them. Again, the visualization and the search function, as described here, could aid to solve the problem. In this case, the edit function was not necessary since the original document would not be modified. However, accessing the whole text of the TMMi was essential to decide on the dependencies. Thus, the initial version was updated to make the hyperlink function available. The hierarchical structure of the PAs is represented by nested boxes and all practices are represented on the screen. The practice name is transformed into a hyperlink, where the text of this practice is accessed.

As shown in Figure 1, the hyperlink function does not impact the steps of the visualization-process. In the SeEd-Visual, the use of this function corresponds to clicking on the practice name and, then, the whole text of this practice is open on the screen. The user can open as many practices as needed.

The SeEd-Visual has been implemented in Java by using the IDE NetBeans 6.7 (NetBeans, 2001). The visual metaphor of the tool uses the Tree-map technique (Johnson and Shneiderman, 1991) from the Prefuse library (Prefuse, 2012).

It is important to observe that although there are some tools that use the tree-map technique (Clarkson et al., 2009); (Newsmap, 2010), none of them provide the edit and the hyperlink functions as presented here. These functions, although simple, have been implemented in the SeEd-Visual since they are useful to handle large volume of data or large documents. In the next section, two case studies that exploring the functions will be presented.

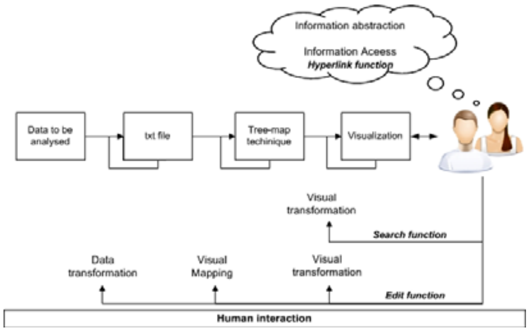


Figure 1: The process supported by the SeEd-Visual tool (adapted from Card, Mackinlay, Shneiderman, 1998).

4 CASE STUDIES

In this section the problems that motivated the process definition and the current version of the SeEd-Visual tool are presented. The first problem – the one related to the questionnaires – is presented as Case Study 1 and the second – related to the TMMi – is presented as Case Study 2.

4.1 Case Study 1: Questionnaires Analysis

One of the basic instruments for the evaluation, planning and support of the decision making on public policy establishment is the production of agile and accurate data. Therefore, the amount of data should be large enough to allow this kind of analysis.

The Brazilian Institute INEP has recorded data for twenty years now, aiming to characterize the Brazilian educational sector. These data have been collected through the national evaluation system, which involves different types of evaluations, generating a rich set of data – each evaluation is composed of approximately eleven questionnaires with about seventy questions each. In spite of the amount of data, they are not standardized and are distributed in different databases.

Mainly because some questions were written in a different way, it was not possible to use an automatic tool to identify when they presented the same meaning. Therefore, this identification requires a human decision. However, as the amount of data was large, some computational support was necessary since the task would be time consuming and error prone if done just manually.

Hence, the visualization-based process was defined and used to make this task easier. Certainly, in case of having a visual scenario of the questions status − groups of identical questions, questions that were used only once, etc. – this information could facilitate the questions analysis and standardization.

Aiming at facilitating the explanation of this case study the data of SAEB (Basic Education Evaluation System), which is the system evaluation for school students (from 6 to 15 ages), were used. This evaluation has been applied every two years and its data corresponded to 66 questionnaires and 5.711 questions. The figures of this section represent a set of questionnaires that correspond to the discipline “Portuguese”.

Figure 2 shows how the process of Figure 1 was applied in this case study. In summary, the questionnaires must be prepared generating a txt file, which is uploaded into the SeEd-Visual tool. The tool transforms the txt file into a visual metaphor, where each question is represented by one box of the tree-map visualization. After that, the questions are processed iteratively through the *search* and the *edit* functions. Every time a question is edited, the tool reorganizes the questions (boxes) automatically by providing a new visual metaphor. Below, each step of the instantiated process of Figure 2 is detailed.

1) *Prepare raw data to be uploaded into the SeEd-Visual tool*= join all questionnaires in a single txt file.

2) *Upload the .txt file into the SeEd-Visual tool*=The data are visualized as shown in Figure 3, where:
 a) each box corresponds to a question;
 b) each box is coloured according to the year when the question was applied;
 c) white boxes that group a set of colored boxes correspond to a question that was applied by using the same syntax (see the top left corner);
 d) isolated boxes correspond to questions that were not applied more than once (not with the same syntax) (see the bottom right corner);
 e) the information presented when clicking on a box contains: the question, the database attribute name, the attribute type, the year when the question was applied and the questionnaire name.

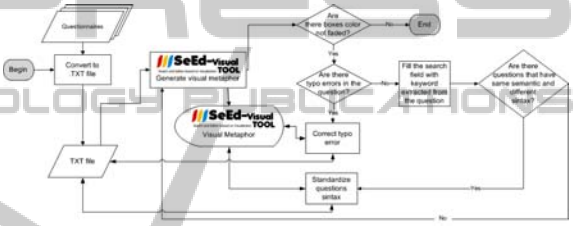

Questionnaires
Begin
Convert to TXT file
SeEd-Visual TOOL
Generate visual metaphor
Are there boxes color not faded?
No
End
Yes
Are there typo errors in the question?
No
Fill the search field with keyword extracted from the question
Are there questions that have same semantic and different sintax?
Yes
SeEd-Visual TOOL
Visual Metaphor
Correct typo error
TXT file
Standardize questions sintax
Yes
No

Figure 2: Flowchart of the visualization-based process of the questionnaire analysis.

3) *Standardize the data*= if there is any non faded box, the user should use the *search* function aiming *to ana*lyze the highlighted questions and, if necessary, edit them. The following actions must be executed:
 a) Click on a non faded box and identify a keyword;
 b) Type the keyword in the search field. Immediately, all the boxes that contain such keyword will become gray, as indicated by the circles in Figure 3;
 c) Analyze the questions of the gray boxes and decide if they have the same meaning;
 d) Standardize the text of these questions (using the edit function), by choosing the most appropriated syntax. The SeEd-Visual tool regroups the questions (boxes), automatically, and fades their colors to indicate that these questions have been analyzed;
 e) Repeat actions (c) and (d), until the syntax of all gray boxes are analyzed;
 f) Go back to action (a) until all the boxes are faded.

After the execution of step 3, the data represented in Figure 3 generates the visualization of Figure 5(a).

Observe that in Figure 5(a) there are fewer isolated boxes and more questions that have been grouped. The isolated boxes correspond to questions that that have been applied only once.

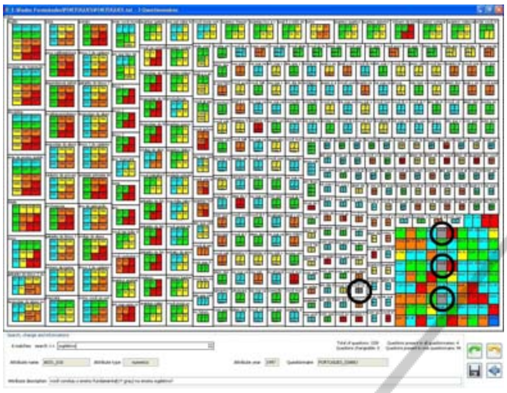


Figure 3: The questions highlighted contain the same keyword.

Figure 5(b) shows the impact of applying the visualization-based process on the SAEB evaluation data. For example, the numbers related to the "*Português*" questionnaire, considered in this study, are highlighted in this figure. After the usage of the functions search and edit combined with the tree-map visualization, the questions that were applied to all questionnaires increased from 4 to 24 and the questions that were applied in only one questionnaire decreased from 94 to 25.

Observe a similar situation occurred for the questionnaires of the other disciplines. In other words, the application of this visualization-based process enhanced the quality and the usefulness of the data, since a more accurate analysis can be done and the amount of common data increases.

4.2 Case Study 2: Structured Reading

After the development of the first version of the SeEd-Visual tool, another problem has arisen: the need to establish dependencies among the TMMi practices (TMMi Foundation, 2011). This model is reference model structured in Levels, Process Areas (PAs), Goals and Practices. To solve the problem, it was necessary to compare all practices, in pairs, aiming to identify if there were dependencies between them and, if so, determine their type.

Aiming to execute this comparison it was necessary to identify the practices that addressed a specific subject, ie, a keyword. Then, to analyze possible dependencies, it was necessary to read the practices description.

Considering the availability of the SeEd-Visual tool, it was adapted to aid in the solution of this problem. As the TMMi document has a hierarchically organized text, the tree-map visualization was ideal to present it and to highlight all the practices that addressed a subject, through the application of the *search* function. Thus, the major modification on the tool was related to the structured reading, which was necessary to handle the information appropriately. This modification allowed the creation of a hyperlink between an item of the TMMi structure and the respective text in the TMMi document, which was transformed into a HTML file.

In this case study the visualization-based process presented in Figure 1 was instantiated in the flowchart of Figure 4.

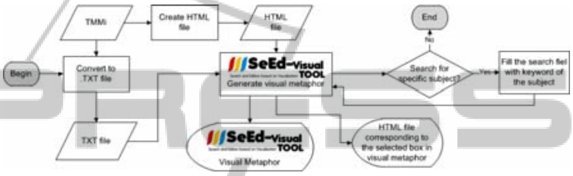


Figure 4: Flowchart of the visualization-based process of the questionnaire analysis.

First, two files are generated from the TMMi document. One of them is a txt file, which contains the structure of the reference model (Process Area, Goals, Practices and Practices Descriptions), and is uploaded into the SeEd-Visual tool. The other one is a HTML file that is used to access parts of the TMMi document, depending on the item of the reference model that was selected by the user. The tool transforms the txt file into a visual metaphor, where each practice is represented by a box of the tree-map visualization. After that, the search function can be used to identify the TMMi practices that address the same subject, and then can be interdependent.

Below, each step of the process for structured reading, shown in Figure 6, is detailed.

1) *Prepare the TMMi information to be uploaded into SeEd-Visual tool*= create a .txt file that contains the TMMi structure: Process area, Goal and a short description of the Specific Practice.

2) T*ransform the TMMi file into a HTML*= create a HTML file correspondent to the TMMi document, containing hyperlinks in the titles of the structures (process areas, goals and practices). The hyperlinks should be equal to those contained in the .txt file uploaded into the SeEd-Visual tool.

3) *Upload the .txt file into the SeEd-Visual tool*= the data are visualized as showed in Figure 6(a), where:

a) each colored box corresponds to a practice, but unlike case study 1, the colors do not represent a special piece of information (A);

b) white boxes grouping a set of colored boxes correspond to a goal (B);

c) the outer level of grouping, i.e., a set of goals, correspond to a process area (C);

d) the information presented at the bottom side, when clicking on a box contains: the practice, its goal and process area, beyond the practice descriptive text (D).

4) *Upload the .txt file into the SeEd-Visual tool*= the data are visualized as showed in Figure 6(a), where:

a) each colored box corresponds to a practice, but unlike case study 1, the colors do not represent a special piece of information (A);

b) white boxes grouping a set of colored boxes correspond to a goal (B);

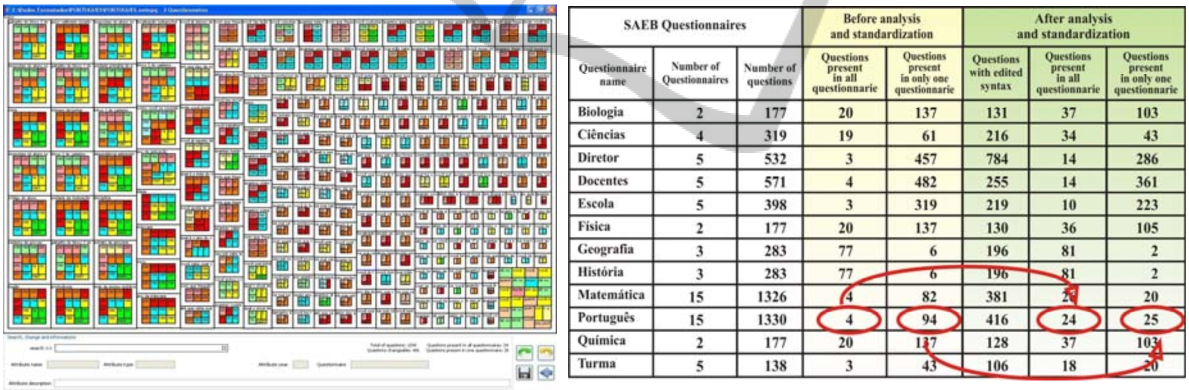
c) the outer level of grouping, i.e., a set of goals, correspond to a process area (C);

d) the information presented at the bottom side, when clicking on a box contains: the practice, its goal and process area, beyond the practice descriptive text (D).

Aiming to establish the dependencies, the user must provide the subject for which he wants to find the related practices. This is done through the search function, as in case study 1. As soon as he provides a keyword for that subject, all the boxes that contain such keyword will immediately become gray, as indicated in Figure 6(b). This visual result also allows realizing the impact of that subject on the TMMi reference model as a whole. As an example, in Figure 6(b), the keyword "criterion" was provided to the search function. The gray boxes indicate that this word appears in three different PAs.

After the identification of the PAs that address the desired subject, the user can access the text of the TMMi practices to analyze if they present dependencies, i.e, in case the application of a practice depends on the other one. Each double-click on a gray box opens a HTML file (that conteins the TMMi practice), which allows displaying the practices in parallel, enabling the comparison in pairs (Figure 6 (b)).

The structured reading herein presented makes the handling of TMMi document easier. In this case the visualization provides a better comprehension of the document and facilitates its analysis. In addition,

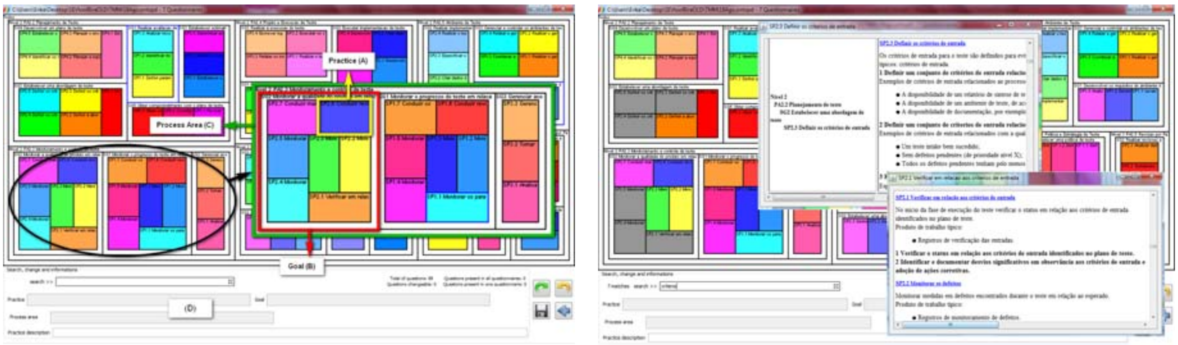


SAEB Questionnaires			Before analysis and standardization		After analysis and standardization		
Questionnaire name	Number of Questionnaires	Number of questions	Questions present in all questionnarie	Questions present in only one questionnarie	Questions with edited syntax	Questions present in all questionnarie	Questions present in only one questionnarie
Biologia	2	177	20	137	131	37	103
Ciências	4	319	19	61	216	34	43
Diretor	5	532	3	457	784	14	286
Docentes	5	571	4	482	255	14	361
Escola	5	398	3	319	219	10	223
Física	2	177	20	137	130	36	105
Geografia	3	283	77	6	196	81	2
História	3	283	77	6	196	81	2
Matemática	15	1326	4	82	381	[illegible]	20
Português	15	1330	4	94	416	24	25
Química	2	177	20	137	128	37	103
Turma	5	138	3	43	106	18	20

(a)

(b)

Figure 5: (a) The same data presented in Figure 3 after the analysis and standardization. (b) Numbers on the SAEB metadata before and after the analysis supported by the visualization-based process.



(a)

(b)

Figure 6: a) TMMi visualized in SeEd-Visual tool. b) The result of the search function applied with the keyword "*criterion*" (in gray) and the text of two practices selected through hyperlinks.

this kind of reading can be applied to different domains, for example, laws, standards and manuals.

5 CONCLUSIONS

This paper presented the use of tree-map visualization combined with the functions search, edition, data regrouping, and hyperlink navigation as a practical solution for data analysis.The use of these functions in a coordinated way facilitates the interaction of the user with the tool, enhancing the human cognition capacity.

This proposal was derived from the need of analyzing a large amount of data, but this analysis would be easier in case all the data were visualized at the same time. Thus, aiming to take advantage of the full screen, the tree-map visualization has been chosen. Besides, the data (a set of questions) must be corrected (ie, edited), triggering immediate regrouping in the visual metaphor. The aim was grouping the data as much as possible. In addition, to identify which data must be corrected, the search option should also be available. Hence, this initial proposal – tree-map, search, edition and data regrouping – was implemented in the tool named SeEd-Visual, which has been the basis to solve similar problems.

After this first problem, it was needed to establish a practical way to handle the large document of the TMMi reference model. It was necessary to read the description of its practices with the aim of deciding if there was any dependency among the ones that were related to a specific issue. Again, a whole overview of the document structure requires the tree-map visualization. The search function solves the problem of identifying which practices should be read. But the reading still requires the access of the TMMi practice full text. Then, the hyperlink function was added to the SeEd-Visual, allowing a structured reading, simultaneously, fragments of this large document.

In summary, the tree-map technique was a good choice to provide a view of the whole data and the functions search, edit, regrouping and hyperlink made the interaction between the user and the visualization easier. As further work, the SeEd-Visual will be used as the basis for the development of a free tool that can be used in the context of qualitative analysis to support the coding technique application.

ACKNOWLEDGEMENTS

The authors wish to thank the Brazilian funding agencies CNPq, CAPES and FAPESP, the INEP institute, the *Observatório da Educação* project and INCT-SEC (National Institute of Science and Technology - Critical Embedded Systems - Brazil), processes 573963/2008-9 and 08/57870-9.

REFERENCES

Burley, D. 2010. Information visualization as a knowledge integration tool. Jounal of Knowledge Management Practice, 11(4).

Card, S., Mackinlay, J. and Shneiderman, B., 1998. Readings in *Information Visualization: Using Vision to Think*. Morgan Kaufmann; San Francisco, 1999.

Clarkson, E, Desai, K. and Foley, J., 2009. ResultMaps: Visualization for Search Interfaces. IEEE Trans. Visualization and Computer Graphics, 15 (1).

Eler, D. *et al.*, 2009. Visual analysis of image collections. The Visual Computer, 25 (10), pp. 923-937.

Johnson, B., Shneiderman, B. 1991. Tree-maps: a space-filling approach to the visualization of hierarchical information structures. In. *Conf. Visualization*, IEEE Press.

Kan, Z., Hu, C., Wang, Z. Wang, G. and Huang, X., 2010. NetVis: A network security management visualization tool based on treemap. In. *Inter. Conf. Advanced Computer Control*, IEEE Press.

NetBeans, 2012 - Java IDE (Integrated Development Environment) [online] Available at: <www.netbeans.org> [Accessed 20 January 2012].

Paulovich, F., Oliveira, M., Minghim, R., 2007. The Projection Explorer: a flexible tool for projection-based multidimensional visualization. In. *BR Symp. Computer Graphics Image Processing*, IEEE Computer Society.

Paulovich, F. *et al.*, 2008. PEx-WEB: content-based visualization of web search results. In. *12th Inter. Conf. Information Visualisation*, Elsevier.

Prefuse, 2012. Visualization toolkit [online]. Available at: <http://prefuse.org > [Accessed 20 January 2012].

Shannon, R., Quigley, A. and Nixon, P., 2010. Deep Diffs: visually exploring the history of a document. In *Inter. Conf. Advanced Visual Interfaces*, ACM New York.

Rübel, O., et. al., 2010. Coupling visualization and data analysis for knowledge discovery from multi-dimensional scientific data. Procedia Computer Science, 1(1), pp. 1757-1764.

Silva, S., Santos, B. S. and Madeira, J. 2011. Using color in visualization: A survey. Computers & Graphics, 35 (2), pp. 320-333.

TMMi Foundation, 2009. The Test Maturity Model Integrated - TMMi Reference Model [online] Available at:<http://www.tmmifoundation.org/html/tmmiref.html > [Accessed 20 January 2012].

HCIL, 2003. Human Computer Interaction Lab, University of Maryland [online] Available at: <http://www.cs.umd.edu/hcil/treemap> [Accessed 20 January 2012].

Wu, Y. et al., 2010. OpinionSeer: interactive visualization of hotel customer feedback. IEEE Trans. Visualization and Computer Graphics, 16(6), pp. 1109-1118.

Newsmap, 2010. [online] Available at: <http://newsmap.jp> [Accessed 20 January 2012].