Technical Report

*User-Centered Development of Information Visualization Methods*

Asgaard-TR-2004-3

**Margit Pohl, Silvia Miksch, and Monika Lanzenberger**
Vienna University of Technology
Favoritenstrasse 9-11/187+188, A-1040 Vienna
martig@igw.tuwien.ac.at, {silvia, lanzenberger}@ifs.tuwien.ac.at

Vienna
Sept. 2004
User-Centered Development of Information Visualization Methods

Margit Pohl
Vienna University of Technology
Favoritenstr. 9-11/187, A-1040 Vienna
margit@igw.tuwien.ac.at

Silvia Miksch and Monika Lanzenberger
Vienna University of Technology
Favoritenstr. 9-11/188, A-1040 Vienna
{silvia, lanzenberger}@ifs.tuwien.ac.at

ABSTRACT
The development of new methods and their implementation within a useable tool is a time-consuming task and involves different users having different types of models of understanding. Making these different models explicit can help to solve problems in software development projects at an early stage. Participative development process and an ongoing evaluation are necessary to capture the whole process. Our overall goal is to study the development process and to improve it according to the users’ need and predefined goals. We are studying the development of the LinkVis method, which facilitates the task-specific exploration of time-oriented and highly structured data. An important feature of LinkVis is the multiple view approach, which is supposed to give users new insights about the data by presenting them three different forms of information visualization. We will illustrate the design principles of LinkVis and our evaluation study.

Author Keywords
Information Visualization Methods, Participative Systems Design, Multiple Views, Evaluation

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Tracking and especially comparing psychotherapeutic processes is a complex task involving a large number of complexly related parameters. Therefore, descriptive and classical statistical methods are only suited for partial analyses. Information Visualization (InfoVis) methods can be used to overcome those problems. The LinkVis method is an example for such an approach. An important feature of LinkVis is the multiple view approach which is supposed to give users new insights about the data by presenting them three different forms of visualization (Chernoff faces [2], parallel coordinates [3], scatter plots). We selected two different geometric visualization methods, parallel coordinates and scatter plots, because both are appropriate for our specific data and well known by the users. Whereas scatter plots separate the data according to two dimensional visualizations, parallel coordinates focus on the courses of the data lines relating all dimensions. Both have a number of advantages but also some shortcomings. In addition, we included a totally different approach by using the Chernoff faces. Such Glyphs using facial attributes to encode data provide the user with overview information. They stimulate interpretation processes in a different manner.

To ensure that this method is adapted to human cognitive processes and helps users to solve their tasks a participative development process and an ongoing evaluation is necessary. User participation is usually a very time-consuming process. Therefore, in the LinkVis project we also conduct a study about the organization of user participation and possible problems which can arise in this process. The participants of the LinkVis project have different interests, their models of the system which is being developed vary accordingly. Making these different models explicit can help to solve problems in software development projects at an early stage. In the following, we will describe the LinkVis methodology and the study about the process of the LinkVis development. First results from this ongoing study are presented.

LINKVIS – THE TOOL
In cooperation with two psychologists LinkVis [4] is developed. It is a tool for visualizing complex psychotherapeutic actions and their effects. LinkVis is based on three different types of InfoVis techniques, two selected techniques can be combined at a time (multiple views): Chernoff faces\(^1\) [2], scatter plots, and parallel coordinates [3]. The user can display datasets by selecting two of these techniques mentioned above. Figure 1 shows the dataset of 4 dimensions for 2 patients and 3 dates visualized by Chernoff faces and parallel coordinates.

\(^1\) Modified similarly to the faces of Emotivate Cartoon Agent, Emotivate Inc. (http://www.emotivate.com/ossdemos.htm).
Scatter plots simultaneously. The third view – parallel coordinates – is shown in Figure 2. The combination of different views and the exploration of these combinations enable the user to get new insights. The strength of LinkVis is its ability and functionality to interactively explore various dimensions of complex time-dependent data. The work of North and Shneiderman [7] indicates that the use of multiple views can be advantageous for some kinds of tasks. We want to test whether this is also the case with complex medical data.

Mainly using evaluation data, the program is developed in parallel to a clinical study of anorectic girls. However, this tool can be used for other applications belonging to the same problem class as psychotherapeutic research and quality control. Psychotherapeutic processes are very challenging tasks and these processes need sophisticated methods to analyze the effectiveness, benefits, and limitations of various treatment options and to compare the treatment courses. Such analyses include a large amount of complex and time-dependent data that are difficult to explore by descriptive and classical statistical methods. During this clinical study a lot of questionnaires are collected. The amount of data is about 6000 questions per patient over one year. The goal of LinkVis is to visualize the questionnaires of the patients. Up to ten questions (parameters) can be combined within one visualization item. The user selects and abstracts in order to find sufficient conclusions to compare group and individual therapy. Each technique offers advantages and disadvantages, moreover, the data can be interpreted differently. If the user sees different aspects within the two visualizations, she or he will try to relate them and find analogies and contrasts.

Chernoff Faces

This face can represent up to 10 dimensions, e.g., by the size of eyes, slope of eyebrows, size and form of the mouth, and so forth. We tend to see the face as a whole, so this technique is very effective in communicating relative values and an overview. This kind of representation is based on the metaphor of emotions because the faces communicate different moods. The data, even the data set of one patient could result in very different facial expressions. However, the advanced user is able to get important information at a glance comparing these faces easily and perceiving relative values.

2D Scatter Plots

This technique is well known and widely used. In contrast to the Chernoff faces, absolute values are easily recognized by looking at the values on the axes, although the user will detect clusters or data holes firstly. The
combination of Chernoff faces and Scatter plots will provide additional information because every technique presents the data differently.

**Parallel Coordinates**

In contrast to the 2D scatter plots, this technique places all axes vertically in parallel to each other (compare Figure 2). The data set is displayed by one line per record and the arrangement of the axes is important. We can rapidly record clusters of lines. Thus uncommon patterns will attract users attention.

![Figure 2: Parallel Coordinates visualizing 4 dimensions for 2 patients and 3 dates. From top left to right: BDI, BDI, SPS, MRF, SF. The 3 dates are represented by the 3 different axes.](image)

In contrast to Chernoff faces and scatter plots, parallel coordinates offer two important features: Many dimensions can be combined in one graph. Similarly to the Chernoff faces, this method provides the user with overview information, but is not charged with the possibly confusing metaphor of emotions, especially if applied to psychotherapeutic data sets. In addition, the user can easily recognize absolute values.

**EVALUATION AND RESULTS**

The LinkVis method is developed with the active participation of the future users and in an interactive manner. Bødker and Iversen [1] point out the importance of reflection and transcending the users’ current practice. It is easier to integrate such an approach into a scientific project like LinkVis than into a commercial project because its schedule is more flexible. So far, there are six people involved in the LinkVis project, two psychotherapists (the future users of the LinkVis methods), two computer scientists and two developers. Mock-ups and prototypes are developed and tested at specific stages. The therapists are usually involved in the development process of these mock-ups and prototypes. Several methods of testing are being used, among them observation of the users and interviews with the users. So far, LinkVis is only developed for a very restricted group of users, but we assume that it can also be used for other therapeutic processes. Therefore, more systematic testing of LinkVis is planned with bigger samples of potential users at the end of the developing process. The aim of the current tests is to find out whether the proposed forms of visualization (Chernoff faces, scatter plots, and parallel coordinates) are appropriate for the data which are used in the project and if they can support the therapists in their work. User studies in other contexts indicated that for longer viewing times (two seconds), eye size and eyebrow slant were the most accurate features. These initial results indicate that Chernoff faces may have a significant advantage over other iconic visualizations techniques for multidimensional InfoVis [5].

**Participative Approach**

The project described in this paper adopts a participative approach. Norman [6] pointed out that the mental models programmers have about software systems can differ fundamentally from the models the users have. It can, therefore, be assumed that a participative approach in software development is not always straightforward as different stakeholders can have different interests. In the LinkVis project the future users (the two therapists) are integrated into the development process to a high degree. Originally, the various visualization methods were suggested by the two computer scientists. The users were especially interested in the Chernoff faces because of this method’s potential for expression. In this method, psychological variables are translated into the mimic and other characteristics of a human face. The therapists found this methodology of visualizing data more intuitive than the others. The Chernoff faces first suggested by the computer scientists conveyed little emotion (see Fig. 3), so the therapists themselves looked for other implementations of Chernoff faces on the WWW and found a more expressive one which is now used (see Fig. 1). They themselves chose the six faces which form the frame of reference for the Chernoff faces (the Chernoff faces which represent good vs. bad states of the patients) in a long process of elimination of unsuitable solutions. This frame of reference is slightly problematic. The eyes in the solution which is used right now (see Fig. 4) do not form a sequence of logical patterns but a psychological sequence. The faces represent happy states (left), aggressive states (middle; aggressivity is supposed to accompany a period of increased insight of the patients), and sad states (right), and those eyes were chosen which expressed these states best. The consequence of this decision is that it is rather difficult to keep the individual forms of eyes and their significance in mind which was also noticed by the therapists themselves later on. They, therefore, suggested that the six faces forming the frame of reference (see Fig. 4) should be present when any interpretation of data is made.

![Figure 3: Chernoff face visualizing 10 parameters.](image)

![Figure 4: Reference faces showing six different states from good (left) to bad (right) state.](image)
The users made several suggestions concerning extended scatter plots and parallel coordinates (as, for example using the same color for a single patient in all visualizations).

Interviews

The aim of the interviews was to make the different mental models of the system being developed of the computer scientists and the users more transparent. The interviews were conducted by a psychologist via email. The psychologist is not directly involved in the project. The main questions which were asked concerned the precise problem which the LinkVis methodology is supposed to solve, possible misunderstandings between computer scientists and users, the necessity for an early definition of the LinkVis methodology and a description of the history of the project. The interviews indicate that the precise problem the LinkVis methodology is supposed to solve has to be refined by the project team as the project advances. All participants in the project denied that there were any misunderstandings between the different groups in the project. Apparently, “misunderstanding” is a concept with a negative connotation which does not reflect the productive discussions in the project. On the other hand, there are some issues which are slightly controversial which were also mentioned during the interviews, especially the question of the usefulness of Chernoff faces. As mentioned above, the users are quite convinced of the advantages of this methodology whereas the computer scientists are more skeptical because it is difficult to differentiate reliably between different values in Chernoff faces.

User Testing

For the user testing, the mock-ups shown in Fig. 1 and 2 were developed. They were given to the two therapists before the user testing to get acquainted with it. During the user testing the therapists interpreted the data. Only few and reduced data sets were used to get a first impression of the usefulness of the methodology. Apparently, it is necessary to “learn” the use of such methods of visualization. The act of interpretation was not absolutely straightforward for the therapists. They moved from a table with the underlying data to the various visualization methodologies back and forth. Nevertheless, both mentioned that they learned something new from the visualizations which they could not derive from the quantitative data alone. They both found the Chernoff faces very interesting, appealing and motivating. Both also mentioned a problem with the scatter plots and the parallel coordinates. The numerical equivalent of the different states of the patients (good vs. bad) are comparable to the systems of marks at school to make them more intuitive (1 representing a good state and 6 representing a bad state). As a consequence, scatter plots and parallel coordinates are contradictory in themselves. In the scatter plots, for example, a positive development is represented by an arrow pointing towards the lower left corner of the coordinate system. This is counterintuitive. Both users argued that this should be changed.

CONCLUSION

The LinkVis project is an ongoing project using a participative approach. First tentative results indicate that different stakeholders have different views about the project, especially concerning Chernoff faces. The therapists involved in the project found the Chernoff faces extremely interesting and motivating whereas the computer scientist and developers are more sceptical about this method of visualization. The aim of the project is the development of a usable visualization tool for therapeutic data. Future research in the project is supposed to show which form of implementation of visualization tools is the most effective for this goal. The user group right now is very small but we hope to be able to generalize our results and test them with more potential users.

ACKNOWLEDGEMENTS

We would like to thank the psychologists Susanne Ohmann and Christian Popow as well as Herbert Herzog for the project cooperation.

REFERENCES


