The Hyperbolic Hypotheses Tree

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Abstract: We developed a prototype of a visualization tool called LinkVis. It is a tool for visualizing complex psychotherapeutic actions, their effects and the states of the patients. The combination of different views enables the user to get new insights. Focusing on exploration tasks by the user we enhanced this tool by the Hyperbolic Hypotheses Tree. This feature supports the user in defining goals and getting an overview in order to overcome the gap between highly abstracted information about the states of patients on the one hand and interpretation of details of graphical representations on the other hand.

Introduction

Information Visualization (InfoVis) methods and techniques offer enormous potentials for representing complex data in an efficient way and facilitate the exploration of data. In cooperation with two psychologists LinkVis [Lanzenberger03] is developed (compare Figure 1). It is a tool for visualizing complex psychotherapeutic actions, their effects and the states of the patients. It is based on three different types of InfoVis techniques, two selected techniques can be combined at a time (multiple views): Chernoff faces [1][Chernoff73], scatter plots, and parallel coordinates [Inselberg87]. The user can display datasets by selecting two of this techniques mentioned above. 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. It aims at making psychotherapeutic processes accessible and comparable in and between individuals and groups at any given time point and according to its content and time-based dimensions. 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.

LinkVis offers a lot of possibilities for exploring the data. However, it seemed to be a problem that the user could get lost in data space. Therefore, we expand LinkVis and introduce the Hyperbolic Hypotheses Tree we describe beneath. First we want to analyze and classify typical exploration processes, which take place when LinkVis is used.

Exploring and Finding Hypotheses with LinkVis

The most important actions to explore and find hypotheses using LinkVis can be summarized as followed:

1. Comparing selected Chernoff faces with their corresponding values in the scatter plots or the parallel coordinates and vice versa.
2. Remembering or looking up the wording of the question when reading the value of the answer.

[1] Modified similarly to the faces of Emotivate Cartoon Agent, Emotivate Inc. (http://www.emotivate.com/ossdemos.htm).

3. Looking for pronounced visualizations, e.g., typical or rare characteristics.
4. Comparing combinations of values per patient, e.g., each face represents one patient.
5. Comparing the answers (values) of a patient and her parents.
6. Recognizing changes over time of a patient's state.
7. Concluding from meaningful combinations of questions on patients' states.
8. Concluding from patients' to predictions on group therapy or individual therapy.

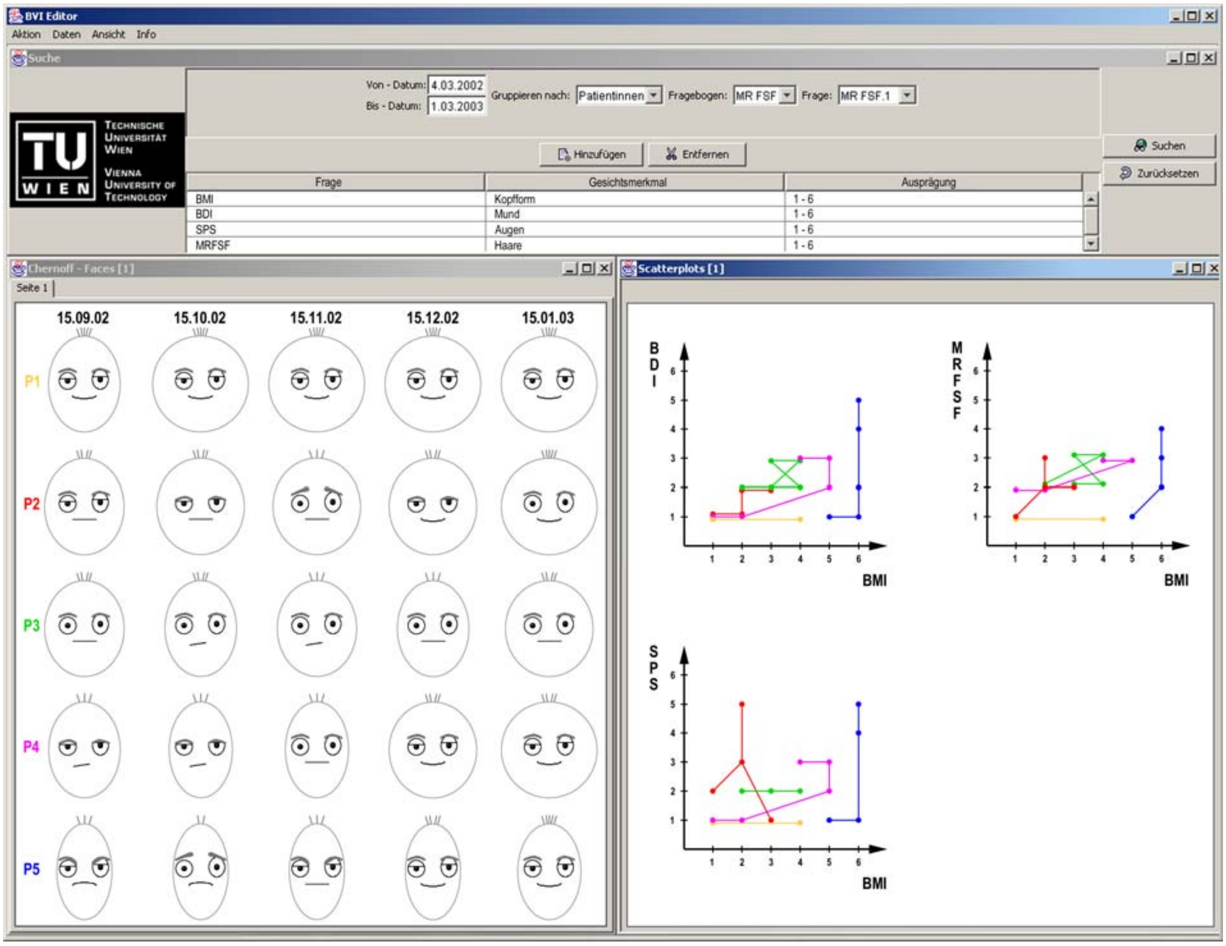

Figure 1: Screenshot of LinkVis depicting 4 dimensions for 5 patients and 5 dates. Dimensions: BMI: Body Mass Index, BDI: Beck Depression Inventory, SPS: Social Phobia Scale, MRFSF: Self Gratification.
Values from 1 (good state of the patient) to 6 (critical state).

We identify three clusters. First, the user looks up values and relates them to the wording of the question (items 1 to 3). Second, she concludes from selected values to the state of a patient (items 4 to 7). Third, she evaluates group therapy in comparison to individual therapy by concluding from the patients' states (item 8). However, strict discrimination and classification of these three clusters is neither possible nor sufficient because they are interwoven and often happen at the same time influencing each other dynamically. Moreover, it is a cyclical process. LinkVis offers graphical representation for the first and the second cluster but not for the third. Looking up and restoring interesting visualizations one by one is not enough. In order to support concluding and reasoning adequately additional functionality is needed.

The Idea of the Hyperbolic Hypotheses Tree

Generally, exploration without definition of goals is an unpredictable process in terms of results and time needed. Sometimes important insights happen by accident, this process is called serendipity [Schulmeister97]. However, the user could become frustrated if she is not able to get an overview of the content. In order to avoid the feeling of getting lost in data space our tree structure supports in getting an overview and defining exploration goals. Each node of such a tree represents an idea or, moreover, a hypothesis. Usually a tree is strictly hierarchical. It could be a problem to represent knowledge or data, which is semi-structured or not structured at all by a tree. Exploration processes are characterized by finding connections within semi-structured or unstructured data. Therefore, we need to adapt the structure of the tree. In order to get more flexibility we distinguish different types of nodes we describe beneath. Every node is specified by a keyword and linked to certain visualizations the user generated before. In addition, the user can append notes describing her considerations about this visualizations or a hypothesis. The user constructs the tree in parallel to exploring the data. The idea of the Hyperbolic Hypotheses Tree is to represent the knowledge of the user and support extending and navigating it. These trees are usually complex. In order to handle such complex trees and use space efficiently, we decided to apply a focus and context technique, in particular, the Hyperbolic Tree [Lamping95]. The Hyperbolic Tree is a distortion-oriented technique, which looks like a tree with the nodes being appliqued on the surface of a globe. If the user focuses on a certain node, this node is placed in the center and gets more space than the peripheral nodes. Therefore, the user can see the details but does not lose the context at the same time.

Structure of the Tree

First of all every tree has a root node. We distinguish two types of nodes: Hierarchical nodes and nodes of equal status. Hierarchical nodes, like parent or child nodes, and siblings describe clear hierarchies. Nodes of equal status are: Subsidary nodes, which add information to another node (+); Restricting nodes, which limit the information of another node (-); Negation nodes, which are the antithesis of another node (!). A node of equal status is always linked to another node. If a node of equal status is not linked to any hierarchical node it is linked automatically to the root in order to give them higher priority and visibility. Furthermore, the brightness of a node indicates the relevance and correctness of its information. Figure 2 gives an impression of the Hyperbolic Hypotheses Tree. Interaction with the tree, like navigating and extending it is crucial in order to understand the structure and build up a mental map of

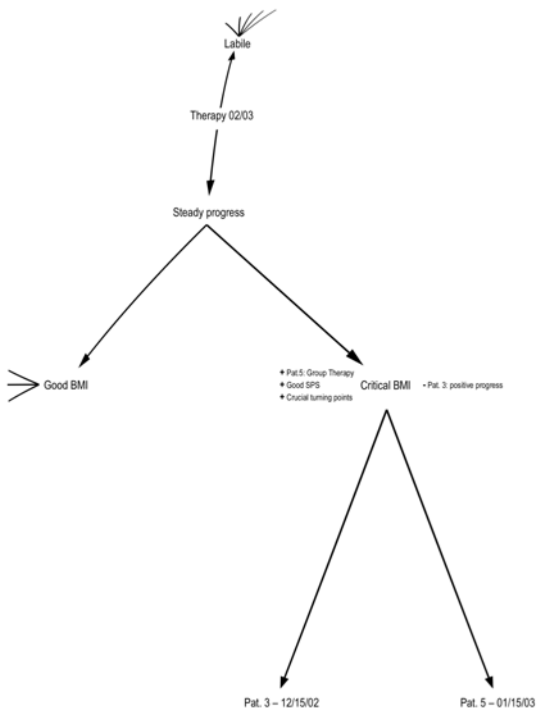

Figure 2: Mockup of the Hyperbolic Hypotheses Tree showing a node about critical BMI states in the center.

the information represented. Interaction with visualizations plays an important role in identifying meaningful patterns and active learning [Card99]. Three types [Sedig02] of interaction can be distinguished: manipulation ("handling it"), navigation ("walking on it"), and issuing commands to it ("conversing with").

Interaction with Visualizations as a Learning Process

Direct interaction with visual representations supports cognitive processes and submits learning from a constructivist point of view. Constructing and using the Hyperbolic Hypotheses Tree in LinkVis enables the user to build up a mental map of the information and to look for relevant data. It aims in both, abstracting and refining statements. Users prefer graphical overview maps in order to orient themselves and navigate the content in an efficient way [Lanzenberger02].

Conclusion

LinkVis enables the user to interactively explore psychotherapeutic data. First tests of LinkVis showed, that we need to overcome a gap between highly abstracted information about the states of patients on the one hand and interpretation of details of graphical representations on the other hand. In order to support such processes like abstracting, concluding, and reasoning adequately, additional functionality is needed. Therefore, we introduced the Hyperbolic Hypotheses Tree, which assists the user in defining goals and getting an overview. Our work is an ongoing process. Next, we will do detailed user testing to examine the effectiveness of the Hyperbolic Hypotheses Tree.

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