VisuExplore: Gaining New Medical Insights from Visual Exploration

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Abstract
Overcoming information overload is a major challenge in current healthcare practice. Interactive Information Visualization methods are promising tools for physicians to ease this situation. We present our VisuExplore prototype, an interactive Information Visualization application for exploring patient data. Its user-centered design and development process involves physicians to match their requirements and needs. The VisuExplore prototype visualizes a flexible selection of medical parameters over time. It provides a range of interaction techniques, and is designed to be easy to use as well as unambiguous to interpret.

Keywords
Information Visualization, Medical Information Systems, Interaction Techniques, Time-Oriented Data

ACM Classification Keywords
H.5.m [Information Systems]: Information Interfaces And Presentation (e.g., HCI)—Miscellaneous; J.3 [Computer Applications]: Life and Medical Sciences; I.3.6 [Computing Methodologies]: Computer Graphics—Methodology and Techniques.

Introduction

The application of modern technology in clinical practice leads to a massive increase in quantity and complexity of electronically available medical data. Thus, medical records have become a write once read never medium [5] and users of current commercial hospital information systems ask for alternative, more intuitive solutions. Interactive *Information Visualization* (InfoVis) is an instrument to overcome information overload and to make information from multiple heterogeneous data sources comprehensible. Particularly in healthcare, *time-oriented data* plays a central role, but time has a complex structure and time models of parameters relevant to patient care diverge [1]. Thus, physicians can use InfoVis methods to analyze changes of patients' conditions, evaluate therapeutic interventions, and recognize trends, patterns, and relationships between parameters over time [6]. For handling such diverse and complex sets of medical parameters, physicians need advanced interaction mechanisms for their InfoVis systems. Obviously, these *interaction techniques* need to be easy to use, so that, above all, they do not hinder patient care, but improve it.

This paper presents our VisuExplore prototype, which allows physicians to visualize medical data available in the hospital information system and, thus, helps them do their daily tasks. Physicians can choose multiple medical parameters of varied time and data models and analyze these in a simple and unambiguous fashion. The prototype is based on LifeLines [4], but uses additional visualization and interaction techniques. Further, we present our working methods as a case study for interdisciplinary collaboration and we summarize the requirements emerging from our introductory user study.

User-Centered Design Process

Intensive study of *tasks and data of target users* is key to any successful InfoVis project [3]. For the VisuExplore project an interdisciplinary project team collaborates, which involves not only InfoVis researchers and physicians of a local hospital, but also human-computer interaction (HCI) researchers and experts in hospital informatics systems. We apply methods of user-centered design [7] as outlined below (Figure 1):

- For introductory input to the project, *interviews* with five physicians resulted in general requirements and an overview of medical tasks and parameters.
- A *contextual observation* with one more physician and a registered nurse yielded deeper insights into the users' needs.

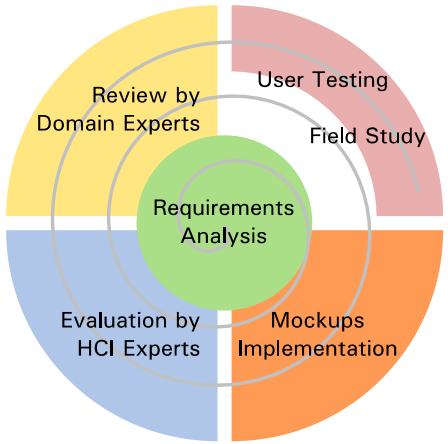

Figure 1: User-centered design process in the VisuExplore project

- Then, we started an iterative process of the InfoVis experts designing visualization and interaction techniques and physicians and HCI experts giving feedback. Earlier iterations involved *paper mockups*, and then we worked with *software prototypes*.
- For the final iterations, *usability experiments* are planned and a *field study* will conclude the project.

Requirements

Based on the introductory interviews with five physicians and contextual observation the following key requirements emerged:

- Simple user interface: The interfaces should be particularly clear, simple to use, and make it possible to gain unambiguous insights.
- Flexible for various medical parameters: Different patients or different medical disciplines require the analysis of different sets of parameters.
- Time-oriented data: Various measurements of a parameter over time need to be followed.
- Multiple patients: Data of multiple patients needs to be compared to find out whether some therapies are more effective than others.
- Interactivity: A variety of interaction techniques such as (semantic) zooming, filtering, grouping, opening medical documents from the visualization, and writing annotations should be included.

Interactive Prototype

Based on the requirements listed above, we designed a prototype for interactive visual exploration of medical data. The diabetes outpatient clinic was selected as prototypical medical scenario. Figure 2 presents a typical screenshot with four visualizations that are in alignment with a common horizontal time axis. The visualizations shown are well-known representation techniques for categorical and numerical data: Event chart, line plot, bar chart, and timeline chart. They form the basic package of the prototype because they are easy to use and interpret for physicians without extra training.

The prototype's interactive features allow physicians to get an overview of multiple medical parameters and focus on parts of the data. Physicians can add visualizations with one or more additional parameters. They may resize and rearrange visualizations. Further, it is possible to navigate and zoom across the time dimension by dragging the mouse, by using dedicated buttons, or by selecting predefined views (e.g., last

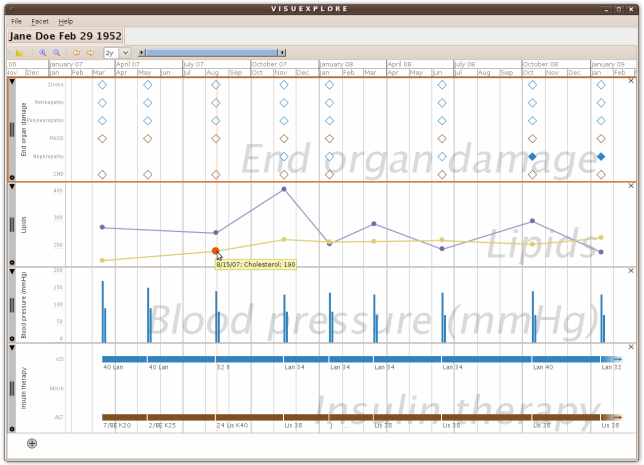

Figure 2: VisuExplore prototype showing categorical and numerical data for a diabetes patient (anonymized medical data)

year). Moreover, the prototype allows selecting and highlighting data elements.

Other time-based visualization and interaction techniques can extend the prototype to support special purposes. For example, the document visualization technique shows medical documents (e.g., discharge letters) as document icons (e.g., PDF, Word) that physicians can click on, if they want to open the document. The prototype integrates with the hospital information systems and accesses the medical data stored there. It uses the Java libraries prefuse [2] for visualization.

Future Work

As the prototype described above is still under refinement, more visualization and interaction techniques are being added. One particular direction for future work is the integration of data from patient cohorts. For example, physicians might want to compare medical values of a patient with their cohort over time. Further, we aim to provide annotation facilities, so that physicians can write down their medical insights directly within the visualization.

Finally, a key question is how InfoVis applications will be used in clinical practice: How much interactivity can physicians fit into their busy schedules? We need to examine this in user studies. Especially, field studies will be invaluable sources of information.

Conclusion

InfoVis provides powerful tools for patient care to ease the information overload of the medical staff. We presented our VisuExplore prototype, an interactive InfoVis application for exploring healthcare data. Its user-centered design and development process involves physicians to match their requirements and needs. Our VisuExplore prototype visualizes a flexible selection of medical parameters over time. It provides a range of interaction techniques, and is designed to be easy to use as well as unambiguous to interpret.

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