Interactive Visualization to Optimize Treatment Choices for Individual Patients

Theresia Gschwandtner*

Institute of Software Technology & Interactive Systems, Vienna University of Technology

Abstract

In recent years sophisticated approaches have been developed to permit computerized processing and visualizing of clinical practice guidelines. However, visualizing the various interdependencies between the execution of a treatment plan and the patient's condition is still a largely unresolved task. To fill this gap we will develop a prototype dealing with this task along with interactive means to support the exploration of effects of applied treatment plans on selected parameters of a patient. Thus, we allow physicians to assess success or failure of previously applied treatment plans and to optimize the therapy for the individual patient.

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

1 Research Problem and State of the Art

Clinical practice guidelines (CPGs) provide recommendations for specific clinical situations to support clinical decision-maker with the best available scientific evidence. However, sometimes there is more than one equally applicable treatment plan and the need to optimize the choice among them, i.e. to tailor the therapy to the individual patient. This has led us to developing an interactive visualization which allows physicians to more easily investigate the effects of previously applied treatment plans and clinical actions on the patient's condition and thus to enable them to make decisions based on better information.

Recent Information Visualization (InfoVis) approaches of visualizing clinical data focus either on the representation of patient data [8, 9], or on the representation of computerized treatment plans [4, 7]. These approaches draw only an isolated picture of one of the two interacting data sets. There are only very few approaches visualizing both treatment plans and patient data in combination, notably CareVis [1] and Midgaard [3] which provide detailed solutions to specific problems (e.g. visualization of complex time constraints or patient data at various abstraction levels). All of these approaches, however, neglect the importance to explore the various interdependencies between the choice of a specific treatment plan and the patient's condition.

2 Data Analysis and Requirements

We have conducted a detailed analysis [5] of the visualization-relevant characteristics of these two interconnected sets of data, focusing on (1) the application of treatment plans and (2) the corresponding condition of the patient. This analysis has resulted in the following list of requirements:

1. Visualizing the nesting of treatment plans and sub-plans,
2. Visualizing the execution sequence of treatment plans,
3. Visualizing relevant characteristics of treatment plans (i.e., whether a plan is activated or aborted, its effects etc.),
4. Drawing a comprehensive picture of a patient's condition and its evolution over time, and
5. Providing means to make interrelations between applied treatment and the patient's condition transparent.

3 Research Questions

One main and three sub research questions have been formulated.
Main Question:

- How can Information Visualization support a detailed analysis of - and adequate reaction to - the various interdependencies of a patient's health condition and the applied treatment (plan)?

Sub Questions:

- How can a patient's condition and its change over time best be visualized in relation to the applied treatment plans?
- Which parameters and which degree of detail/abstraction of data concerning a patient's condition and the applied treatment plan(s) are best suited to provide a compact overview?
- How can the choice of different possible therapies (depending on the patient's condition) best be supported?

4 Methods

Based on the given list of requirements, we are about to design and prototypically implement an interactive visualization. As mentioned above, selected visualization approaches already provide sophisticated solutions for certain aspects; for instance, CareVis [1] handles the visual representation of complex information of treatment plans (i.e., temporal constraints, nesting of plans, and plan characteristics) in an intelligible and comprehensive way and the Midgaard project [3] provides elaborate techniques to visualize huge amounts of patient data. It seems a good idea to take these approaches as a starting point to develop a consistent visualization combining the advantages of both. However, the main task of making transparent any interrelations between a patient's condition and applied treatment plans has not been addressed yet. Besides an appropriate visualization of patient data and treatment plans, easily usable interactive means have to be provided to allow the user to explore the data, thus enabling him/her to derive decisive insights into the effects of different therapies.

4.1 Design and Evaluation

We strive to attain a user-centered design process by creating mock-ups of the visualization and presenting them to a limited set of users with the intention of detecting problems of understanding, utility, and usability at an early stage of development. We will then modify the visualization prototype with respect to the outcome of these

*e-mail: gschwandtner@ifs.tuwien.ac.at

sessions. This intervention will be repeated in a later stage of the development process.

Physicians being the actual end users, we will encourage a small group of physicians to evaluate these mockups. In case we can not recruit enough physicians, we will switch to medical students or students of medical informatics. (Another feasible way of detecting usability problems: A heuristic evaluation with the participation of 3-5 usability experts [6].)

In a late stage of this project, a qualitative assessment (e.g., a case study, scenarios of use, or reports of new insights) will be conducted to evaluate the benefits of the developed prototype. The given research questions will serve as criteria to evaluate the outcome of this project.

5 Work Performed so Far

We have analyzed the visualization requirements resulting from the characteristics of relevant data. Moreover, we have carried out a detailed investigation of existing approaches and useful techniques [5]. In doing so, we have obtained a comprehensive picture of existing visualization approaches dealing with related topics; we have also explored existing techniques that can be re-used for further development. Recently, we have started to design some visual encodings and interaction mechanisms as described in the following subsection.

5.1 Visual Encodings and Interaction Mechanisms

We have devised a visualization technique to encode the success and failure of treatment plans. For instance, the intended effect of a treatment plan may be: "temperature should be reduced to less than 38°C". We code the approximation of the patient's actual temperature towards the intended value by a gray scale (see Figure 1) as such a scale has an implicit ordering (i.e. it can immediately be interpreted by the eye). The association of dark with "bad" (regress) and light with "good" (progress) thus entails an intuitive mapping. The actual temperature at the start of the treatment plan is associated with 0% success and the intended value with 100% success. In case a treatment plan comprises more than one effect (e.g., reduction of temperature **and** white blood cells), it can be visually encoded either by two *SuccessLines* or by one *SuccessLine* representing the overall success (where each parameter is weighted according to its importance). The *SuccessLine* allows for getting an immediate idea of the progress of the applied treatment plan and facilitates the comparison of alternative plans.

In addition, clinical actions contained in a treatment plan are indicated above the SuccessLine. The limited set of well distinguishable colors [10] is sufficient to color-code these actions.

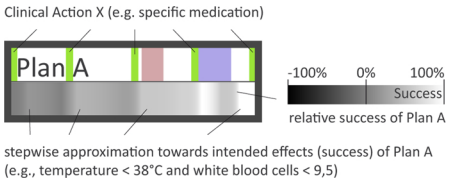

Figure 1: Visual encoding of a treatment plan containing clinical actions and the approximation towards intended effects of the plan.

Moreover, we will provide interactive means (1) to compare **different treatment plans** and their effects on the patient's condition, (2) to compare **selected actions** and their effects on the patient's condition (see Figure 2), and (3) to find and compare **patient parameter patterns** in combination with applied treatment plans (we intend to provide a tool to select an area of interest in the parameter curve and subsequently, align similar patterns of this parameter for comparison - similar to the functionality of the *SearchBox* of TimeSearcher 2 [2]).

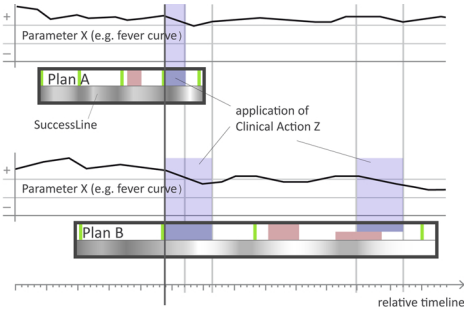

Figure 2: Mockup: Comparison of Plan A and Plan B with regard to the effects of the Clinical Action Z on Parameter X. The different degree of success (depending on Parameter X - optionally depending on more than one parameter) of Plan A and Plan B is visualized by the SuccessLines of the plans.

6 Further Work

Further work comprises the completion of the interface-design, the conduction of mockup testing sessions, and both the implementation and the evaluation of the prototype.

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