Supporting Medical Personnel at Analyzing Chronic Lung Diseases with Interactive Visualizations

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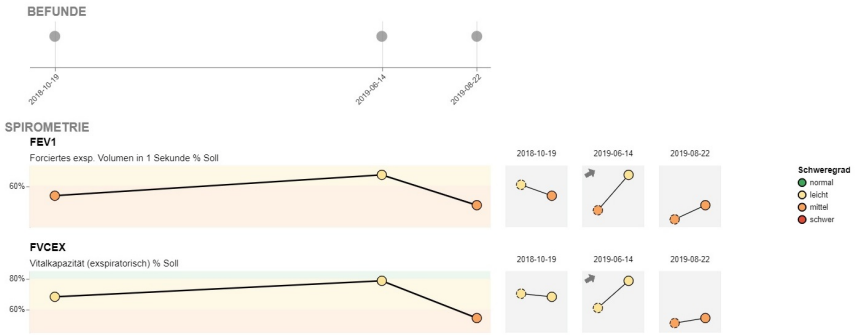

Figure 1: *Partial view of our prototype showing spirometry measures. Each line chart depicts the progression over time, color-coded by severity. The dates are presented as a timeline, while the pre- and post-treatment values of each exam can be analyzed via the slope charts.*

Abstract

We present a visualization system for medical practitioners to analyze lung function data collected at different points in time. In particular, our approach aims to solve the problems practitioners encounter in their daily work life when they have to consult different text-based documents to get access to the same data we provide in a single interface. To test the suitability of our system, we conducted a formative study where participants used our system to answer both simple and complex questions previously designed in collaboration with a domain expert. Our results indicate that our target users can easily work with our system and use it to answer both types of questions.

CCS Concepts

• ***Human-centered computing*** → ***Visualization systems and tools; Empirical studies in visualization; Visual analytics;***

1. Introduction

In medical practice, visual analytics can improve the productivity of medical personnel, allowing users either to analyze data more thoroughly or increase the speed at which the data is evaluated. This in turn may improve the diagnosis of diseases (see [SPH13]). Lung function exams provide data that is helpful in evaluating breathing patterns for conditions like asthma. Existing systems for analyzing lung function data, both analog and digital ones, do not show results for multiple pulmonary function tests simultaneously, thereby forcing the physicians to separately analyze all relevant pieces of information [DJC17]. In contrast, our prototype incorporates all lung function parameters of each available patient exam but also allows for the inclusion of other laboratory data such as eosinophils.

Our prototype, akin to many other works in health data visualization [RAM*11, LPK*16], emphasizes effective exploration of time-oriented medical data, facilitating comparison of a disease at different points in time. Hence, our approach does not aggregate exams, as done in Dabek [DJC17], and shows each lung function test in detail while still allowing for an overview of the overall progression. Furthermore, our approach specifically focuses on lung function data obtained from medical exams and does not present electronic medical records (EMR) in general [ZWA*13].

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In this poster, we present our approach, showcase the visualizations, and share first insights and lessons learned from our formative study with healthcare professionals.

2. Prototype Design

We designed our prototype in collaboration with domain experts over the course of a workshop. Together with five pneumologists and two visualization experts, common tasks and routinely asked questions were gathered and sorted by relevance. Using these it was possible to develop a first draft for the visualization, which was iteratively refined using expert feedback.

Afterwards, the resulting design was implemented as a web-based application. This was named as a mandatory requirement, since it can not be guaranteed that the medical personnel has the required expertise and access to install software on their device. Furthermore, it increases the mobility as the interface is not limited to a specific device. Our system consists of multiple connected components that allow the user to interpret and analyze the different medical exams and their measurements.

Patient selector and general information In the header of the interface, the user can select the patient using a dropdown component. Furthermore, the header contains basic information about the patient such as age, gender, weight and height.

Overview charts Below the header a section with small multiples of area charts was added, allowing the user to get a good overview, even for a larger number of measurements.

Line charts The main components are the interactive line charts, that allow the user to analyze the different measurements over time and in detail (see Figure 1). Each line chart supports zooming and panning, and each data point provides information like the absolute value when hovering over it. Additionally, a percentage of the recommended value is shown, in case such a value is defined. Finally, each data point and the different areas of each chart are color-coded to show the varying categories (e.g. *reduced*, *normal* and *elevated*).

Slope charts Since each finding can be the result of a treatment, it is possible for an exam to contain two values. A value before the treatment took place (pre) and a value after it took place (post). As only the post value is presented in the line chart, an additional visualization is needed to show the difference between the pre- and post-value. To achieve this, slope charts where added next to each line chart, allowing the user to inspect and analyze the improvement of each treatment (see Figure 1).

3. Study

To evaluate the usability of the web interface, we conducted a small formative study in the form of small expert interviews.

Design

For this study, four pneumologists from different hospitals in Germany were interviewed for a duration of 30 minutes. We asked each participant questions to test common scenarios that might occur in the day-to-day working activities of the target group. The questions were designed in correspondence with an expert for the assessment of lung function data. Said expert also provided correct answers for each question to test against and selected the patient data used for the study. Both the questions and answers were validated by a second expert. For each interview, the screen and audio were recorded to allow for detailed analysis afterwards. One of the four interviews was discarded due to technical problems with the recording.

Results

Participants largely gave valid answers to the study-questions that matched the experts' expectation or were open for debate. The feedback of the participants was mostly positive, with a general comment being the easy comparison and the fast access to data as useful features. However, a close analysis of the interview recordings revealed several possibilities for improvement. On the side of minor issues, our visualizations may lack accessibility due to low contrast in some places like the colored bands. In addition, although suggested that way by an expert, the line charts do not show the pre values, which could be solved through a different visual design. We identified the following four issues as the most common and important ones.

Identifying the Date of a Measurement Since it is important for the user to know when a measurement was taken, the visualization always displays a time-axis, allowing the user to read the date, without using the tool tip. Unfortunately, some users struggled to identify the date on several occasions.

Overview Chart Usage The area charts, which were supposed to give an overview of the different measurements were barely used by participants, if at all.

High Need for Vertical Space It is not always possible to see any pair of line charts at the same time, as the charts are stacked vertically, requiring the user to scroll. This can led to an increased difficulty when the user wants to compare two values or wants to establish a connection between them.

Data-Dependent Horizontal Width Depending on the number of data points for a patient, the visualization may not fill the complete width of the screen or may not fit without horizontal scrolling. This can occur because the slope charts have a fixed size and are aligned next to the line charts, resulting in a variable width depending on the number of data points.

4. Conclusion

In collaboration with domain experts, we designed and implemented a multi-view visualization prototype for the analysis of lung function data for multiple medical exams. Results from a formative study show that our tool allows for fast access and comparison of the data and might thereby improve the analysis of lung function data. All participants generally liked using our prototype and were able to answer domain-relevant questions. Although these results are promising, feedback from participants and their interactions with our tool also indicated several areas for improvement, like the need to scroll in order to compare measures that are far apart in the layout. With the help of these observations, our prototype can be further improved to provide better access to the data. This also presents the opportunity to add further functionality, e.g. to improve the clarity of the interface. We plan to implement these improvements and investigate how our improved prototype compares to other existing approaches in a controlled study setting.

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