

preha: Establishing Precision Rehabilitation with Visual Analytics

Supplementary Material on Initial Interviews and Pilot Evaluation

Georg Bernold, Kresimir Matkovic, M. Eduard Gröller, Renata G. Raidou

Initial Interviews

Interviews were held with six individuals, four of which are Engineers and two are Domain Experts. All of them are used to work in multidisciplinary teams, sharing their experience from technology and rehabilitation medicine. The interviews were designed to get an idea of current technologies and work practice in rehabilitation. The six potential users had never used a Visual Analytics application before. All interviews were performed individually.

The organized interview sessions were about 30 minutes long to one hour and were conducted in the native language of the first author and the interview participants (which is German). All interview sessions were recorded with the agreement of the participants. Two main topics were the subject of the interview. The first is about finding out current work practice of visualization in rehabilitation. The second is a look to the future. A set of questions was prepared for both topics, simply to maintain the flow of the interview. All interviews developed their own pace and provided their individual point of view, which was the desired output.

Domain Experts Interviews

The Domain Experts interview questions were designed to determine current workflows in the rehabilitation context. We aimed to use “do you? questions” to make as little assumptions as possible. The interviews started with brief statements on the current position of the Domain Experts and their background, especially about data visualization. The following questions were asked to learn about the common practices for current exploration and visualization of data:

- Do you share information? How do you share it (Meetings, Video Conferences, ...)?
- How is the collaboration with IT staff like? Do you need them to look up things in the data? (e.g. referrer statistic)
- Do you use visualizations? If yes: which?
- Do you browse through data just out of curiosity?
- Do you use any other data source to obtain information? If yes: which?

- Do you conduct studies with EHR data?
- Do you use applications to deal with data (Excel, ...)?
- Do you write reports, summaries (for management, congress, ...)?
- Do you compare groups of patients with each other?
- Which of the above do you perform, actually? How often?
- Do you let the data influence your treatment?
- What influences your treatment?
- When you do analysis what data do you look at?
- How is the process of looking into the data, describe!
- Would you say data has influence on a patient's treatment?

Furthermore, we aimed to ask the Domain Experts about their expectations from this work. We also focused on possible future trends and their impact on the rehabilitation workflow and tasks.

- What of the above would you be interested in? What else?
- Are you satisfied with the way tasks are fulfilled today?
- What are tasks that should be improved or made in a different way? Can you think of limitations (tools, data, skills, ...)?
- Are there any things that you can imagine, or you want to be more automatic?

Engineers Interviews

The Engineers interview questions were quite similar. We largely focused on current workflows and used “do you? questions” to make as little assumptions as possible, again. At the beginning, we asked for brief statements on current positions and background knowledge, with a focus on artefacts that are produced with data. We prepared the following questions for the interviews:

- Do you share information? How do you share it (Meetings, Video Conferences...)?
- How is the collaboration with domain experts like? Do they want you to look up things in data? (e.g. referrer statistic)
- Do you use visualizations? If yes: which?
- Do you use any other data source to obtain information? If yes: which?
- Do you use applications to deal with data (Excel, ...)?
- Do you write reports, summaries (for management, congress, ...)?
- Which of the above do you perform, actually? How often?
- When you do analysis what data do you look at?
- How is the process of looking into the data, describe!

And again, we prepared questions on possible future usage of data analytics and expected future trends.

- What of the above would you be interested in? What else?
- Are you satisfied with the way tasks are fulfilled today?
- What are tasks that should be improved or made in a different way? Can you think of limitations (tools, data, skills...)?
- Are there any things that you can imagine, or you want to be more automatic?

The transcripts could not be provided as the interviews were conducted only in German.

Pilot Evaluation

The evaluation has been conducted with the Engineers only, as they were easily reachable, and we wanted to hear their comments and concerns first. Based on this feedback, we would like to improve our work and then, conduct a thorough evaluation also with the Domain Experts. For this reason, we conducted an early pilot study with the four Engineers. We stick to the usage scenarios described before for the evaluation. While the usage scenarios were rather focused on a generic view of the many features of **preha**, we find it more suitable for the users to stick to well defined assignment. Therefore, we provide fictive but realistic assignments to be accomplished by the users for each of the tasks. After the user has completed the assignment, we ask them to provide statements on how the application helped them to accomplish the task. The results of this statements are reported for each task. We do not record quantitative features (e.g. time to complete a task) of the user evaluation, as the sample (n=4) is too small for statistically relevant results. We did not want to conduct tasks Exp1-Exp5 with the Engineers, as we may face possible abstraction dangers.

Each evaluation session held with the users started by an explanation of the system. This explanation starts with an overall introduction of the system and a reminder of the intended tasks. An important aspect of our explanations is the dashboard as the centerpiece of our system. We explain the relationship between visualizations and dashboards as well as what different types of visualizations are supported by **preha**. Another important point is the concept of filters and how visualizations in a dashboard are affected when filters are applied. When the users felt comfortable to proceed, we moved on to the next phase.

Pilot Study of Eng1: Provide meaningful data partitions

Assignment

Domain Expert Dr. X works at a rehabilitation clinic with a focus on orthopedic patients. Part of Dr. X's work is to perform scientific research on methods in orthopedic rehabilitation. Dr. X is interested in performing a retrospective study on knee diseases and asks you to prepare a dashboard in **preha**, with a data table as central point of attention. Dr. X wants to perform research on knee injuries. For this reason, data analysis for a retrospective study needs to be conducted, on the following subcohort:

- The age of the patients shall be above 50

- The primary diagnosis of the patients shall be M17, Gonarthrosis.
- Only female patients shall be present.
- Only patients treated in the second half of 2016 (1st of June to 31st of December).

The result of this task shall be a data table with a row for each patient in the cohort, with the columns: ID, age, primary diagnosis, WOMAC ATL score at admission and WOMAC ATL score at admission.

Answer the following questions:

- How many patients are present in the cohort?
- Visualize the distribution of the WOMAC ATL admission score. Create a bar chart that shows the average value for age groups of 10 years.

Findings

As this is the very first task each user must accomplish, we predefine the encoding techniques to be used. In this case this is the data table. We observe that it takes all users a few minutes to find out how to add a new visualization. This could have possibly been prevented by additional explanations, but one user states: "I prefer to find out some aspects on my own, this helps me to memorize it my own way". Creating the subcohort did not rise any difficulties among the users, especially adding filter buttons is one of the users' preferred solution for filtering the subcohort.

Pilot Study of Eng2: Prepare templates for patient assessment

Assignment

In rehabilitation, it is important to include the patient as much as possible in the treatment process. Part of this process is to discuss the progress of the treatment at time of discharge. The domain expert Dr. Y asks you to provide a dashboard that supports this process. Dr. Y wants to present the results of their two minutes walking test to individual patients. Furthermore, it is of interest for the domain experts to show the patients how they compare to other patients of the same age group (10 years), sex and diagnosis. For this reason, a dashboard with the following elements needs to be prepared:

- A visualization that shows the distribution of the two minutes walking test admission and two minutes walking test discharge each.
- A metric that shows the results of the individual patient for admission and discharge each.
- A filter button, that enables fast changing between individual results and all results.
- A filter button to set the sex of the patient.
- A filter button to set the age of the patient.
- A filter button to set the primary diagnosis of the patient.

Answer the following questions:

- What are the peaks of the distribution of the two minutes walking test in the observed sub group?
- What is the difference of the admission and discharge value of the individual patient?

Findings

The most important aspect of this assignment was to determine a good way to present the distribution of the two minutes walking test. Some users decided on taking the range criteria for buckets, where the range of each bucket must be specified, which takes more time to complete. Generally, we observe that the users are way faster in creating visualizations, dashboards and filters which is no surprise as they start getting familiar with the system after having completed the first task. Still, the users tend to be overwhelmed if they need to freely choose encoding techniques. The questions defined were answered easily by all participants of the evaluation.

Pilot Study of Eng3: Prepare templates for clinical benchmarking

Assignment

Clinical benchmarking is a tool used by healthcare facilities to monitor and improve their quality and efficiency. Ms. Z, head of the administrative staff at rehabilitation clinic W, needs some key indicators on the clinical performance. For a specific timeframe, it is of interest how many patients received a treatment in total, how the patient admissions developed, how the WOMAC ATL discharge score developed and how the shares of payers are partitioned. For this reason, a dashboard with the following elements needs to be prepared:

- A metric that shows the total number of patients.
- A bar chart showing the shares of the individual payers.
- A line chart that shows the development of patient admissions.
- A line chart that shows the development of the WOMAC ATL discharge score.

Answer the following questions:

- Describe the development of the WOMAC ATL discharge score during 2017.
- Identify two outliers in the patient admission development line chart. What are possible reasons for that?

Findings

For Eng3 we again face an improvement on how confident the users are with using **preha**. One user stated that the learning curve is “a bit steep first, but once you are familiar with the basic interactions, the system feels very intuitive”. None of the users has troubles when it comes to creating the metric. Two users state, that they would prefer using pie charts over bar charts for visualizing the shares of the individual payers. No participant pointed out any development of interest in the WOMAC ATL discharge score line chart. On the other hand, the users were able to clearly see the outliers in the patient admission development, which was explained by Christmas and Easter holidays.

Pilot Study of Eng4: Predict rehabilitation outcome

Assignment

For the treatment of Osteoarthritis, therapy A has been the state of the art for years. Rehabilitation Centre Y has been testing therapy B quite successfully for the very same task for a while now, randomly assigning

therapy-minutes of both therapies to the patients. For both therapies, the WOMAC ATL score is the best feedback measure. Now it is of interest to determine the effectiveness of both therapies. For this reason, a prediction for the discharge score shall be defined that takes the therapy-minutes for each therapy into account. Prepare the following dashboard:

- A visualization that enables specifying the minimum and maximum number of minutes for the two therapies affecting the prediction.
- A machine learning visualization that predicts the score at discharge.

Answer the following questions:

- What are therapy A and therapy B?
- How would you describe the impact of therapy A on the WOMAC ATL score at discharge?
- How would you describe the impact of therapy B on the WOMAC ATL score at discharge?

Findings

Eng4 is the last, but also the most complex task for the engineers. All users start with the predictive analytics part. As this is the first time the users use this visualization, they spend some time to analyze its capabilities. The machine learning visualization is rather complex compared to the other visualizations, some users ask additional questions at this point to fully understand its capabilities. After the users are aware of the machine learning visualizations functionality, they have no difficulties learning what therapy A and therapy B are. Most users aim towards using filters for specifying the minimum and maximum number which is an obvious solution. Now the participants can modify these variables and monitor the difference in the predicted WOMAC ATL score.

General Feedback

After the four tasks have been evaluated with the users, we ask the users for general comments on **preha**. All users agree that **preha** can realize the tasks that were worked out together. Furthermore, the users highlight the multiple coordinated views in **preha** as a central feature and main advantage. The flexibility of the dashboards including rearranging and resizing visualizations is a feature especially like by the engineers. During this work, we designed **preha** in English, however the users suggest providing **preha** in the users' native language. All users state, that they would have required more knowledge to start with the first assignment. On the other hand, the users report that exploring the system on their own helped them getting to know **preha** in their own style. The engineers further suggest preparing extensive training material featuring a lot of examples, before approaching the domain experts. One engineer stated that "the domain experts are not used to work with tools such as **preha**, they lack required technical knowledge". **Preha** features some highly specialized and complex features, as the first evaluation stage with the engineers demonstrated. During this evaluation, a few aspects were pointed out by the engineers. For example, a lack of extensive documentation, a steep learning curve in the beginning, trouble *distinguishing* metrics and buckets, and the oversupply of visualization types. Using this feedback from the engineers, we can improve the functionality of the tool and design appropriately an evaluation that will include also clinical domain experts.