Eurographics Conference on Visualization (EuroVis), Posters Track (2016)
T. Isenberg and F. Sadlo (Guest Editors)

User Interaction Visualization for Design Synthesis

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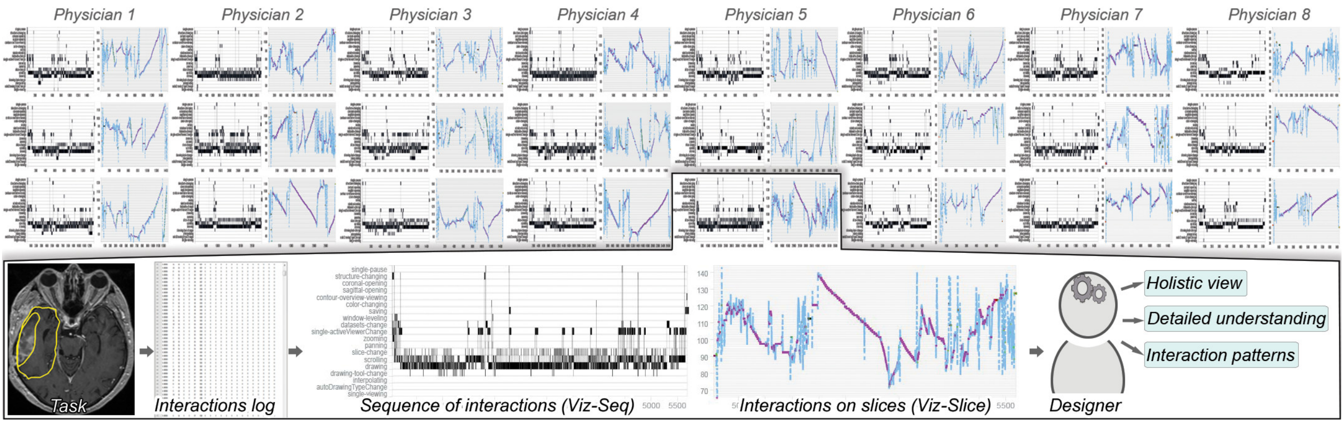

Figure 1: *Visualizations from the case study of the manual tumor contouring task, with a detailed example*

Abstract

Through the synthesis of gathered user research data, interaction designers are able to generate design proposals. Logging user interactions with a software provides a rich set of data that can give further insights into users' behavior. We present a case study of visualizing interactions log files of the manual tumor contouring task. We identify two types of visualizations needed for comprehending the tumor contouring process. Based on these visualizations, designer was able to gain a holistic view of the process, detailed understanding of the different phases of the task, and identify re-occurring interaction patterns.

Categories and Subject Descriptors (according to ACM CCS): H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces—User-centered design

1. Introduction

Design synthesis is an abductive sensemaking process of manipulating, organizing, pruning and filtering previously gathered data regarding users' behaviours, needs and motivations, in an effort to generate design proposals [Kol10]. It is a decisive point in the design process, meanwhile it is also rather complicated and exhausting process due to the large variety and amounts of data [GLM*11].

In the design process, a variety of data is collected regarding the users, by utilizing various user research techniques and methods (e.g., interviews, observations, video recording). In addition, there has been increased interest in capturing human computer interaction events (such as mouse clicks and key strokes) in a log file (e.g., [GGZL16], [JCD*16]). Such interaction log files can be a rich source of data for comprehending the fuzzy user behavior. However, comprehending the raw (typically textual) log files is very challenging for designers due to the limitations of human short-term memory [PW07]. At the same time, design synthesis (a task that has fuzzy task clarity) based on digital data, can benefit from visualization [SMM12].

In this work, we present two visualizations to help the designer to better comprehend information from interaction log files, based on a case study of manual brain tumor contouring on 3D medical image datasets. Based on the outcomes of this case study, we also highlight requirements for an interactive visualization tool that enables grasping user interactions during medical image contouring.

DOI: 10.2312/eurp.20161128

2. Case Study

Tumor contouring is a complicated clinical task, completed through the use of a dedicated treatment planning software. In order to comprehend the behavior of users and to identify requirements for an improved design, we conducted a contouring study where user interactions were captured in a log file. The studied task consisted of two sequential sub-tasks as in a typical clinical routine [BTBJ04]: contouring the Gross Tumor Volume (GTV), and correcting the automatically generated Clinical Target Volume (CTV). In total, eight physicians of varying level of experience joined the study, and each of them contoured three datasets. This resulted in total of 24 cases. Ethical approval for the use of patient data was obtained prior to the study.

The log files created during the study consisted of timestamped low-level events (e.g., mouse-click, mouse-drag, etc.) that were clustered into meaningful software interactions based on the available meta-data (e.g., a cluster of mouse-drag events could be "drawing", "zooming", or "panning" interaction). Two data visualizations were developed using the D3.js library to visualize: 1) the sequence of interactions (*Viz-Seq*) and 2) the interactions on different 2D slices (*Viz-Slice*) as Figure 1.

The *Viz-Seq* view was developed to indicate the shifts between interactions. Each type of interactions (in total 19) displayed in the *Viz-Seq* view had a dedicated horizontal lane, within which each occurrence was represented by a rectangle. The transitions between different interactions were indicated by connecting lines, for easier tracing of the interaction sequences. The *Viz-Slice* view was developed to show the occurring interactions on each slice. In the *Viz-Slice* view, each horizontal lane represented a 2D slice within the 3D dataset, and each interaction was represented by a color-filled rectangle. The designer also had the possibility to select a subset of interactions to be visualized to eliminate visual noise. In both views the width of the rectangle indicated the duration of the interaction. In addition, the designer was able zoom in to a part of the visualization by dynamically changing the time range with a slider. Furthermore, the designer could quickly switch between the different cases.

2.1. Synthesis Results

Based on the visualizations, the designer was able to explore each of the 24 cases both in a holistic and detailed way. The visualizations helped understanding the task process quicker than reviewing video recordings would have been. At the same time, it also allowed visual comparison of the task process (complete or a portion) between users. Furthermore, it was possible to identify reoccurring interaction patterns that gave further insights into typical software use. Below, we will highlight few of the findings.

Based on previous observational studies, we were able to qualitatively conclude that the tumor contouring task consists of three phases: familiarization, action and evaluation. However, the transitions between these phases and detailed interactions during them were not clear. Using the visualizations it was possible to build an in-depth understanding of the three phases. For example, using *Viz-Seq* it was possible to identify that shifting between datasets not only took place at the beginning of the task (familiarization phase), but also at the end of the task (evaluation phase). The action phase, which mainly consists of focused contouring interactions, was clearly identifiable based on both of the visualizations.

Three types of contouring strategies were identified: 1) the physician created a *precise* contour on a slice before moving on to the next slice; 2) the physician created *rough* contours on multiple slices first, and then iteratively revising the contours in each slice until a satisfied result; and 3) a *mixed* approach that combined both strategies at different moments.

Four scrolling patterns and five interaction sequence patterns were identified. These patterns provided a deeper understanding of user interactions in different phases and helped building hypotheses of underlying reasoning processes. For instance, *rapid scrolling* at the beginning of the task could be associated with getting an initial understanding of the case, while the same pattern at the end of the task could be associated with rapid evaluation of the contours.

3. Reflections

Two types of visualizations of the interaction log files are required to comprehend the contouring process: one to support the exploration of interaction sequences; and one to identify interactions in relation to the third dimension of the image dataset. In a setting where video is recorded in addition to logging, it could be beneficial to extend the timeline views by embedding the video recording synchronously.

The vertical order of interaction lanes within *Viz-Seq* was predefined - the least occurring ones first, and frequently interchanging ones (e.g., *slice change* and *drawing*) following each-other. This guaranteed visual consistency and eased visual comparison between cases. As an improvement, using color to differentiate subtypes of an interaction could be beneficial (e.g., *drawing* a new line, *drawing* to edit, or *drawing* to delete).

Log files are commonly analyzed for extracting usability measures, identifying usage patterns, inferring knowledge or expertise [GSB*94]. Our focus was on better supporting inferring knowledge of users and thus we visualized each case separately. Another approach could be to visualize multiple cases at once (e.g., [MS06]).

4. Conclusions

In this paper, we presented two timeline visualizations of log files to explore user interactions based on a case study of tumor contouring: one for visualizing sequences of interactions (*Viz-Seq*), and one for visualizing interactions in relation to the third dimension of the medical image datasets (*Viz-Slice*). Both visualizations allowed the interaction designer to explore the task process in a holistic view as well as in details. Based on the visualizations it was possible to better understand the transition between the phases of the task, as well as the occurring interactions during these phases. Furthermore, the visualizations helped identifying contouring strategies and main interaction patterns. Results from the case study indicate that (*Viz-Seq*) and (*Viz-Slice*) timelines support design synthesis.

Acknowledgement. The research leading to these results was part of European Union project called SUMMER and was supported by European Union Seventh Framework Programme (FP7-PEOPLE-2011-ITN) under grant agreement PITN-GA-2011-290148.

References

[BTBJ04] BURNET N. G., THOMAS S. J., BURTON K. E., JEFFERIES S. J.: Defining the tumour and target volumes for radiotherapy. *Cancer Imaging 4*, 2 (2004), 153–161. 2

[GGZL16] GUO H., GOMEZ S. R., ZIEMKIEWICZ C., LAIDLAW D. H.: A case study using visualization interaction logs and insight metrics to understand how analysts arrive at insights. *IEEE Transactions on Visualization and Computer Graphics 22*, 1 (Jan 2016), 51–60. doi:10.1109/TVCG.2015.2467613. 1

[GLM*11] GUMIENNY R., LINDBERG T., MEINEL C., ET AL.: Exploring the synthesis of information in design processes–opening the black-box. In *DS 68-6: Proceedings of the 18th International Conference on Engineering Design (ICED 11), Impacting Society through Engineering Design, Vol. 6: Design Information and Knowledge, Lyngby/Copenhagen, Denmark, 15.-19.08. 2011* (2011). 1

[GSB*94] GUZDIAL M., SANTOS P., BADRE A., HUDSON S., GRAY M.: *Analyzing and Visualizing Log Files: A Computational Science of Usability*. Tech. Rep. GIT-GVU-94-08, Georgia Institute of Technology, 1994. URL: http://hdl.handle.net/1853/3586. 2

[JCD*16] JORRITSMA W., CNOSSEN F., DIERCKX R. A., OUDKERK M., VAN OOIJEN P. M.: Pattern mining of user interaction logs for a post-deployment usability evaluation of a radiology pacs client. *International journal of medical informatics 85*, 1 (2016), 36–42. 1

[Kol10] KOLKO J.: Abductive thinking and sensemaking: The drivers of design synthesis. *Design Issues 26*, 1 (2010), 15–28. 1

[MS06] MALỲ I., SLAVÍK P.: Towards visual analysis of usability test logs using task models. In *Task Models and Diagrams for Users Interface Design*. Springer, 2006, pp. 24–38. 2

[PW07] PROCTOR R., WU K.: Human information processing: An overview for human-computer interaction. sears, a., jacko, j. a. *The Human-Computer Interaction Handbook* (2007), 43–62. 1

[SMM12] SEDLMAIR M., MEYER M., MUNZNER T.: Design study methodology: Reflections from the trenches and the stacks. *IEEE Transactions on Visualization and Computer Graphics 18*, 12 (Dec 2012), 2431–2440. doi:10.1109/TVCG.2012.213. 1