

Bringing healthcare professionals to the forefront in process mining: novel methods to identify information needs and visualize outcomes

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Abstract

This research project emphasizes the importance of process mining providing the insights that healthcare professionals need. Therefore, it is essential that (1) the analyses match their information needs, as identifying them is a challenge that has not yet been researched in the domain, and (2) that the results are visually presented in a clear way for the healthcare professionals, as they are the end-users and current comprehensible visualization tools for them are limited. The gaps in the literature indicate the topic of this PhD is relevant and will advance the research domain of process mining in healthcare.

Keywords

process mining, healthcare, information needs, interviews, visualization,

1. Introduction

Hospitals are complex organizations facing a multitude of challenges such as addressing care needs with limited resources and managing hospital mergers [1]. Hospital management are often confronted with questions such as: “Why is the waiting time in the ER increasing?”, “What was the impact of our reorganization on the workload of nurses?”, “Which doctor is receiving the most tasks?”, etc. For the hospitals and other health organizations it is important to gain insights into how processes are performed to identify routes to improve processes [2, 3]. All the above hospital management questions can be answered using process mining [4]. There are many benefits of applying process mining in the healthcare sector. For example, Alvarez et al. [5] discover process models from hospital event logs and receive insights on the collaboration and role interaction of healthcare professionals in the emergency department.

Process mining originated from the computer science domain with a focus on creating the fastest and most optimal algorithms with limited attention for the subjectivity and context of some of the ‘human subjects’, such as physicians and nurses with extensive process-related expertise, behind data points [6]. This raises questions on how process mining matches the needs of healthcare professionals (e.g., doctors, nurses, ...). What are the information needs of healthcare professionals with regards to process mining and which methodology can be used


ICPM Doctoral Consortium and Demo Track 2023

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 CEUR Workshop Proceedings (CEUR-WS.org)

to identify these information needs? How can healthcare professionals better understand the process mining outcomes? Which visualization techniques already exist and what are they lacking to present process mining results in a comprehensible way for healthcare professionals? These are the questions this project seeks to tackle.

2. State-of-the-art

A recent review of the state-of-the-art of process mining in healthcare by De Roock and Martin [7] illustrated that process mining has high potential in the healthcare sector, but the uptake in practice is rather limited [2]. The latter is necessary to support solving real-world healthcare problems. The review revealed two main gaps relevant for this project.

First, the information needs of healthcare professionals (e.g., doctors, nurses, etc.) are rarely given explicit consideration when carrying out process mining projects. Several studies [2, 3, 8] emphasize that different stakeholders have different information needs. Information needs have been studied in other domains, but only one study has been done on identifying information needs in process mining projects. Klinkmüller et al. [9] state that information needs are rarely determined in advance of a process mining project. However, the authors explore information needs of stakeholders via BPI challenge reports, they do not interact with stakeholders themselves to explore information needs of stakeholders via qualitative methods such as interviews. Existing process mining methodologies, which describe the steps of a process mining project do not include the identification of information needs either. For example, Aguirre et al. [10] distinguish the steps project definition, data preparation, process analysis and process redesign. Identifying the information needs of the stakeholders is not explicitly part of the steps. There are currently also no guidelines or methods available to systematically map the information needs of healthcare professionals w.r.t. process mining. This is surprising as it is essential to know what kind of information or insights the healthcare professionals wish to obtain, so process mining can respond in a targeted manner. Therefore, in this project, I will devise such a method.

Second, it is important to present process mining outcomes in a visual way that is understandable for healthcare professionals. Only then will it be possible for them to gain insights into their processes and, thus, use process mining as a starting point to identify process improvement opportunities [2]. In domains such as healthcare, with complex processes, good visualization is key to facilitate understanding results. Unfortunately, as stated by Rojas et al. [11], there is a lack of a good visualization of process mining results. In this regard, Aguirre et al. [12] argue that clinicians are not familiar with process mining and there is a clear knowledge gap, making it difficult to interpret the results. Besides, there is a lack of research on the optimal visualization for the end-user, in this case the healthcare professional. Although in recent years, there has been more awareness about the importance of this topic [13], at the moment only very limited research has been done on visualization within the context of process mining in healthcare [14, 15] and even within the entire process mining domain [16, 17]. Therefore, in this project, I will introduce new visualization techniques adapted to healthcare professionals.

Against this background, the aim of my proposal is to tackle two fundamental research challenges which can significantly contribute to the more systematic use of process mining in

healthcare as (1) the analyses performed are in line with the information needs of healthcare professionals, and (2) the results are visualized in a way that is comprehensible to them.

3. Methodology

3.1. Objective 1: Develop a new method to systematically map information needs regarding care processes among healthcare professionals

Currently, there exist no methods to systematically map the information needs of healthcare professionals in the process mining domain. During this research, a novel method will be developed to tackle this objective. This method is the artefact of the design science research methodology of Peffers et al. [18], which is a research approach in which an artefact (in this case the method) is developed and studied. As a first step and as part of the problem identification and motivation of Peffers et al. [18], a literature review on the identification of information needs was conducted. Then, based on the literature, a novel method was developed to identify the real needs of healthcare professionals. Next, the method will be demonstrated in a real-life context at the emergency department of the university hospital of Brussels where the information needs of various staff categories (doctors, nurses, administrative staff and management) will be determined. The goal for this method is not to be context-specific, but replicable in varying healthcare scenarios. This method can be used in the initial phase of every process mining project.

3.2. Objective 2: Develop new visualization techniques to convey process mining results to healthcare professionals in an insightful way

As most clinicians are not familiar with process mining and there is a clear knowledge gap [12], I will develop new visualization techniques that present process mining outcomes in an intuitive way for healthcare professionals.

As a first step, a literature review will be conducted, in which three relevant domains will be examined: (1) research regarding visualization in process mining, (2) studies on the broad domain of 'visual analytics' and, (3) research on visualizing processes in healthcare.

Based on the insights of the literature, new visualization techniques will be developed, which aim to visualize the outcomes of existing process mining algorithms in an insightful way for healthcare professionals. An interesting opportunity for improvement to consider, is visualizing multiple process dimensions in one visual e.g., linking Key Performance Indicators (KPIs) to the visualization of the process. De Roock and Martin [7] stress the need for including KPIs in process mining projects and discussed how KPIs can help a department or hospital reach their ambitions. Therefore, linking KPIs to the visualization can lead to richer and more insightful results for the healthcare professionals. Another area for improvement is visualizing results of conformance checking [13, 19]. Conformance checking has great potential within healthcare (e.g. showing where patient treatment deviates from clinical pathways), but the results of these algorithms generate a lot of fine-grained information [20]. It should be further explored how these results can be presented in an insightful way. Therefore, I will develop a library of visualization techniques which aim to visualize the outcomes of existing process

mining algorithms in an insightful way for healthcare professionals. The techniques will display control-flow models with performance information on the one hand and conformance checking results on the other hand. To this end, these open-source visualization techniques will be made available via an R package or Python library.

Next, I will assess whether the new visualization techniques provide more insights for healthcare professionals, compared to the current standard visualization techniques in process mining. This step will again be validated by demonstration in a real-life context at the emergency department of the University Hospital of Brussels. The feedback of the participants will be collected in a structured way via qualitative research methods e.g., four to six focus groups or 15 to 20 individual interviews at the hospital. I will approach healthcare professionals working in the ER. I will show, for example, models while asking several substantive questions that gauge the understanding of the output. In addition, more qualitative feedback can be requested.

4. Conclusion

To conclude, with this project I aim to (1) include healthcare professionals during a process mining project by developing a new method to identify their specific information needs and (2) to introduce new visualization techniques to present process mining results to healthcare professionals in an insightful way.

As a result, this research contributes to the domain of process mining in healthcare by not only involving the healthcare professionals (and their needs) in process mining projects but also by offering them insights in their data with adapted visualization techniques.

Acknowledgments

This PhD thesis is supervised by Prof. dr. Niels Martin (Hasselt University) and Prof. dr. Filip Van Droogenbroeck (Vrije Universiteit Brussel).

References

- [1] E. Solstad, I. J. Pettersen, G. Robbins, Hospitals as professional organizations and the perception of distances, *Financial Accountability & Management* 37 (2021) 20–36.
- [2] N. Martin, J. De Weerd, C. Fernández-Llatas, A. Gal, R. Gatta, G. Ibáñez, O. Johnson, F. Mannhardt, L. Marco-Ruiz, S. Mertens, et al., Recommendations for enhancing the usability and understandability of process mining in healthcare, *Artificial Intelligence in Medicine* 109 (2020) 101962.
- [3] J. Munoz-Gama, N. Martin, C. Fernandez-Llatas, O. A. Johnson, M. Sepúlveda, E. Helm, V. Galvez-Yanjari, E. Rojas, A. Martinez-Millana, D. Aloini, et al., Process mining for healthcare: Characteristics and challenges, *Journal of Biomedical Informatics* 127 (2022) 103994.
- [4] W. van der Aalst, *Data science in action*, Springer, Berlin, 2016.

- [5] C. Alvarez, E. Rojas, M. Arias, J. Munoz-Gama, M. Sepúlveda, V. Herskovic, D. Capurro, Discovering role interaction models in the emergency room using process mining, *Journal of biomedical informatics* 78 (2018) 60–77.
- [6] K. Crawford, *The atlas of AI: Power, politics, and the planetary costs of artificial intelligence*, Yale University Press, 2021.
- [7] E. De Roock, N. Martin, Process mining in healthcare—an updated perspective on the state of the art, *Journal of biomedical informatics* 127 (2022) 103995.
- [8] T. Grisold, J. Mendling, M. Otto, J. vom Brocke, Adoption, use and management of process mining in practice, *Business Process Management Journal* 27 (2021) 369–387.
- [9] C. Klinkmüller, R. Müller, I. Weber, Mining process mining practices: an exploratory characterization of information needs in process analytics, in: *Business Process Management: 17th International Conference, BPM 2019, Vienna, Austria, September 1–6, 2019, Proceedings 17*, Springer, 2019, pp. 322–337.
- [10] S. Aguirre, C. Parra, M. Sepúlveda, Methodological proposal for process mining projects, *International Journal of Business Process Integration and Management* 8 (2017) 102–113.
- [11] E. Rojas, M. Sepúlveda, J. Munoz-Gama, D. Capurro, V. Traver, C. Fernandez-Llatas, Question-driven methodology for analyzing emergency room processes using process mining, *Applied Sciences* 7 (2017) 302.
- [12] J. A. Aguirre, A. C. Torres, M. E. Pescoran, Evaluation of operational process variables in healthcare using process mining and data visualization techniques, *Health* 7 (2019) 19.
- [13] J.-R. Rehse, L. Pufahl, M. Grohs, L.-M. Klein, Process mining meets visual analytics: the case of conformance checking, *arXiv preprint arXiv:2209.09712* (2022).
- [14] R. C. Basole, M. L. Braunstein, V. Kumar, H. Park, M. Kahng, D. H. Chau, A. Tamersoy, D. A. Hirsh, N. Serban, J. Bost, et al., Understanding variations in pediatric asthma care processes in the emergency department using visual analytics, *Journal of the American Medical Informatics Association* 22 (2015) 318–323.
- [15] V. Kumar, H. Park, R. C. Basole, M. Braunstein, M. Kahng, D. H. Chau, A. Tamersoy, D. A. Hirsh, N. Serban, J. Bost, et al., Exploring clinical care processes using visual and data analytics: challenges and opportunities, in: *Proceedings of the 20th ACM SIGKDD conference on knowledge discovery and data mining workshop on data science for social good*, Citeseer, 2014.
- [16] P. M. Dixit, H. G. Caballero, A. Corvo, B. Hompes, J. C. Buijs, W. M. van der Aalst, Enabling interactive process analysis with process mining and visual analytics, in: *Special Session on Analysis of Clinical Processes*, volume 6, SCITEPRESS, 2017, pp. 573–584.
- [17] W. van der Aalst, M. de Leoni, A. H. ter Hofstede, Process mining and visual analytics: Breathing life into business process models, *BPM Center Report BPM-11-15*, *BPMcenter.org* 17 (2011) 699–730.
- [18] K. Peffers, T. Tuunanen, M. A. Rothenberger, S. Chatterjee, A design science research methodology for information systems research, *Journal of management information systems* 24 (2007) 45–77.
- [19] S. Dunzer, M. Stierle, M. Matzner, S. Baier, Conformance checking: a state-of-the-art literature review, in: *Proceedings of the 11th international conference on subject-oriented business process management*, 2019, pp. 1–10.
- [20] J. Carmona, B. van Dongen, A. Solti, M. Weidlich, *Conformance checking*, Springer, 2018.