Applying Process Mining to the Emergency Department

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INTRODUCTION

Process mining is a relatively young research discipline that sits between computational intelligence and data mining on the one hand, and process modeling and analysis on the other hand. The idea of process mining is to discover, monitor and improve real processes (i.e., not assumed processes) by extracting knowledge from event logs readily available in today's (information) systems. Process mining provides an important bridge between data mining and business process modeling and analysis (W. Aalst et al., 2012).

Process mining research lies on automated process discovery (extracting process models from an event log), conformance checking (monitoring deviations by comparing model and log), social network and organizational mining, automated construction of simulation models, model extension and repair, case prediction, and history-based recommendations.

At the same time, there is a continuous pressure for augmented quality and responsiveness in healthcare services that demand for growing budget needs. Thus, controlling the increasing costs of health care is a prominent item in political and social agenda (Kaymak, Mans, Steeg, & Dierks, 2012). One could easily enumerate a few factors (such as the innovative but costly treatment potentials, the protracted medical care for an ageing population, the particularities in medical operations which require highly qualified personnel, etc.) that leave very few alternatives to reduce the related costs, but to focus on the healthcare processes design and execution. These processes involve clinical and administrative tasks, large volumes of data, and large numbers of patients and personnel. Healthcare organizations have to focus on ways to streamline their processes in order to deliver high quality care while at the same time reducing costs (Kemafor Anyanwu, Amit Sheth, Jorge Cardoso, John Miller, & Krys Kochut, 2003).

A sine qua non condition to proceed towards this direction is to get the related process models documented. These models need to be validated, analyzed (over multiple perspectives e.g. control-flow, performance etc.) and eventually redesigned for improvement. Traditional methods of business process analysis and redesign rely on lengthy interviews and group meetings in order to try to understand how things are working (Wil M. P. Aalst, Hofstede, & Weske, 2003). Adding to the large costs claimed by these methods, the results are essentially subjective and biased by flawed or overemphasized perceptions. Therefore, there emerges a need for methods that would operate

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affordably and more objectively at the same time. Process mining techniques appear to fit as a solution, since they are based on real data (what really happened vs. assumed process models) and comprise a rich toolbox for process analysts and decision makers.

However, process mining techniques can only work when there are data available, namely when an event log for the underlying process exists (or can be created). Hopefully, today's hospital information systems contain a wealth of data (Fichman, Kohli, & Krishnan, 2011). The information systems of healthcare organizations (e.g., electronic health record systems, picture archiving and communication systems) are utilized more and more, contributing to a large volume of healthcare-related data.

Following the event-log availability, this work will demonstrate the potentials of process mining in the healthcare domain, and in particular in the emergency department (ED) processes. These potentials include the identification and visualization of the process paths that are typically followed by patients; the discrepancy of exceptional flows; performance analysis (e.g. identification of bottlenecks); and testing the process conformance to the medical standards.

For this paper we used the open-source software tool ProM (Process Mining Group, 2009) and the commercial tool Disco (Fluxicon, 2012) under an academic license.

PROCESS MINING PROJECT LIFE CYCLE

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Providing Decision Support for the Emergency Department processes requires several additional activities next to the actual process mining analysis. An overview of the lifecycle of a process mining project is presented in (van der Heijden, 2012). Every project begins with the scoping stage where the processes to be mined are identified and the project objectives as well as the techniques that are going to be used are decided. Then, the data stage follows during which analyst have to understand data (locate, explore and verify) and to create the Event Log (select, extract and pre-process data). The actual process mining stage follows. This stage is about answering the research questions through the actual implementation of process mining algorithms. Results evaluation (including verification, validation, accreditation of results) is the next stage while the final stage is about the deployment of the solution (identification of possible improvements and the presentation of results). An instantiation of the above methodology, adjusted for the healthcare domain is presented in (Rebuge & Ferreira, 2012).

In this work, we slightly modified the methodology of (Rebuge & Ferreira, 2012) and we followed the steps described in Figure 1. The main differences between the two methodologies are that (Rebuge & Ferreira, 2012) use sequence clustering (Veiga & Ferreira, 2010) to cluster patients while in our work we abstract from the clustering algo-

Figure 1. Stages for a healthcare process mining project (based on the work of (Rebuge & Ferreira, 2012)