PALIA-ER: Bringing Question-Driven Process Mining Closer to the Emergency Room

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Abstract. This paper presents PALIA-ER, a web-based tool for question-driven process mining in Emergency Room. PALIA-ER uses Palia discovery algorithm and includes model simplification and filtering features specially domain-specific for ER. Most PALIA-ER functionalities can be easily applied to other interdisciplinary contexts such as other healthcare units, education, or logistics.

Keywords: process mining, emergency room, healthcare, BPM

1   Challenges of Question-Driven Process Mining in ER

In recent years, Process Mining has emerged as a powerful and popular tool for the analysis of processes in a wide range of disciplines, such as Education or Healthcare [2]. Healthcare is a good example of this interdisciplinary research: in [3] the authors identify and characterize 74 case studies of process mining in the medical domain. The event data recorded by the Hospital Information Systems (HIS) is used to obtain detailed models and knowledge about the performed processes. Within healthcare, Emergency Room (ER) processes have particular characteristics that make them different: they have short duration (e.g., the episodes last hours instead of days), a well-defined end-point (e.g., an episode typically ends with the patient being hospitalized or ambulatory discharged), and particular phases (e.g., the triage, where the condition of the patient is initially evaluated, and a color-coded priority is assigned). Given the success of Process Mining in healthcare, in [4] the authors proposed a specific question-driven methodology to apply Process Mining in healthcare. This methodology is specially indicated for interdisciplinary research, since it is not technology driven, but instead the questions formulated by the domain-expert are considered the first-class citizens of the analysis. This interdisciplinary methodology presents a series of challenges: 1) process models should be simple enough to be
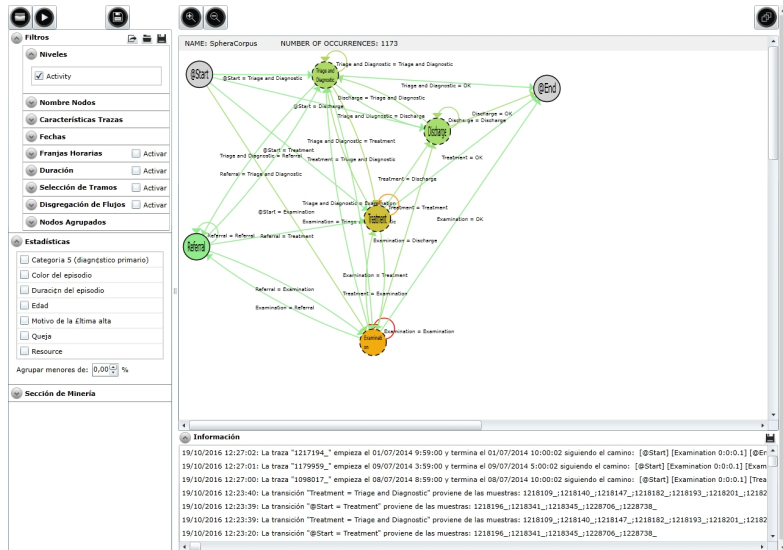
Fig. 1. PALIA-ER Process Mining Tool

understood by researchers not familiar with the BPM discipline (e.g., healthcare professionals), 2) process models should be able to represent in an intuitive way complex behavior typical of such interdisciplinary contexts, 3) event data and process models should be able to be filtered and aggregated to represent the process at the desired level of detail, 4) case statistics should be available in order to lead the process analysis interactively, and finally, 5) it should include domain-specific filter possibilities (e.g., in the ER case, triage, discharge destination).

This paper presents PALIA-ER, a tool for Question-driven Process Mining analysis in ER. PALIA-ER addresses all the aforementioned challenges, and provides the healthcare expert a tool with a complete set of features to analyze their own ER processes. Notice that, although PALIA-ER is ER-specific, most of the concepts and features presented in this work are easily adaptable to other interdisciplinary domains.

This article is organized as follows: Section 2 presents PALIA-ER and its main features. Two illustrative case examples using the tool are illustrated in Section 3. Finally, Section 4 concludes the article.

2 PALIA-ER Process Mining Tool

In this article we present PALIA-ER, a web-based process mining tool designed for question-driven process mining analysis of the ER domain. Figure 1 shows an overview of the tool main elements: the main center panel of the tool is

a. ER filters

b. Activity Naming

NAME: SpheraCorpus		NUMBER OF OCCURRENCES: 1173		
Color del episodio	Duración del episodio	Edad		Motivo de la última alta
100,00 % Naranja	0,38 % 03:03:42	5,44 % 1	27,82 %	Abandono o retiro sin atención
	0,25 % 01:58:54	5,35 % 0	26,05 %	Alta
	0,25 % 03:04:12	4,12 % 2	25,02 %	Alta para transferencia interna / Hospitalización
	0,25 % 04:30:45	3,16 % 3	19,23 %	Alta con control Ambulatorio

c. Statistics

Fig. 2. PALIA-ER Features

used to display the discovered process models and the process statistics; the side bar on the left contains the menus to set the filters, model simplifications, and discovery parameters; finally the panel at the bottom displays information about the analyzed process. PALIA-ER has several features specially designed for ER. In particular, the main ones are:

▷ *Interdisciplinary Process Models and Discovery*: Process Mining tools for interdisciplinary research require process models to be easy to interpret by actors of all disciplines. PALIA-ER uses the Palia algorithm [1] to automatically discover graph-based process models from event data. Those models were first used for indoor location systems data analysis, where complex information needed to be presented in a comprehensive way [1], making them suitable for other complex domains such as healthcare and ER. For the sake of space, we refer the reader to [1] for more details on the models or the discovery algorithm.

▷ *Model Simplification*: PALIA-ER includes features to easily merge or remove activities in order to provide high or low level overviews of the same process, depending on the question being answered. Figure 2b partially illustrates this feature, where providing an existing alias to an activity or unchecking it collapses or hides such activity.

▷ *ER Domain Specific Filters*: PALIA-ER includes case filters based on transversal case properties, common in other process mining tools. For example, filter by date or filter by duration, among other examples. However, the tool also provides easy access to ER domain specific filters. For example, *filter by*

triage color (i.e., the color-based priority of the ER episode assigned during the triage phase), or *filter by last discharge* (i.e., the type of discharge of the last visit, including ambulatory discharge or hospitalize discharge for example). Other examples include filters by the general characteristics of the patient, such as age or gender. For the sake of space, we refer the reader to [4] for more details on the ER domain specific reference model. Figure 2a partially illustrates this feature.

▷ *Statistics*: PALIA-ER provides detailed and aggregated statistics about the cases, allowing the final user to go back and forward on an interactive analysis of the process, filtering such cases not relevant for answering the current question. Figure 2c partially illustrates this feature.

To demonstrate the use of PALIA ER, a screencast with a walk-through of the tool can be found at `http://pmuc.ing.puc.cl/tools/paliaer/`.

3 Case Examples

In this section we illustrate the applicability and potential impact of the tool, by applying it to answer two frequently asked questions by experts in the ER, following our methodology [4]. The scope of the analysis was provided by the needs of the ER experts, who also validated the results. Given the space constraints, the cases are merely teased, but similar, more extensive analysis can be found in [4].

Q1: What is the followed process by all the ER episodes?: The first question relates to the general view of the ER unit. In order to analyze the high-level view, the grouping feature shown in Figure 2b is used to group all the activities in 5 main ER stages (*Triage and Diagnostic, Examination, Referral, Treatment* and *Discharge*). Then, the relations between the ER stages and the start and end points of the process are analyzed. The resulting process model can be seen in Figure 3. A more detailed analysis concludes that significant interactions are been held between the Triage and Diagnostics, Examinations and Treatment stages, followed by the Discharge stage and finally, with less interaction, the Referral stage.

Q2: What is the followed process for patients over 70 years?: Regarding the analysis necessary to answer Q2: First, the data was filtered according to the age of the patient, selecting only patients with 70 years or more. The discovered process model can be seen in Figure 4. When we analyze the statistics of these episodes (cf. Figure 4), we discover one particular characteristic: hospitalization is the highest destination after the patient has been treated in the ER. A more detailed analysis concludes that in these cases, hospitalization is higher than the typical episodes studied in Q1.

4 Conclusions

This paper presented PALIA-ER, a tool for a question-driven process mining for the ER domain. Two conclusions arise: First, the tool can help reduce the
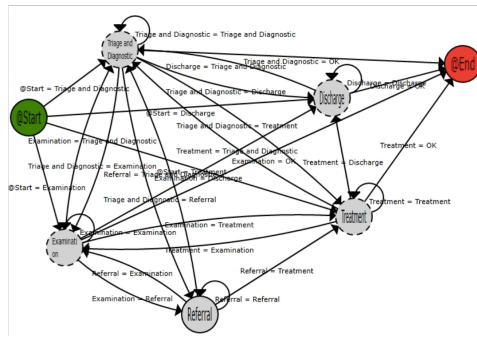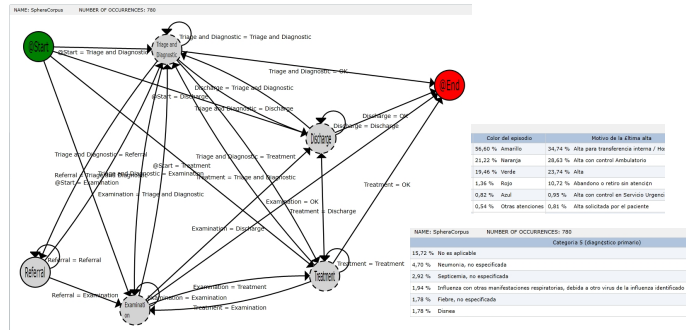
Fig. 3. Q1 Process Model

Fig. 4. Q2 Process Model and Statistics

dependency on the process mining expert from the clinicians looking for solutions to analyze their processes. And second, even though the PALIA-ER solution is ER-specific, it could potentially be applied to other interdisciplinary domains.

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