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Conformance Checking with Regulations – A Research Agenda

Luise Pufahl[1], Jana-Rebecca Rehse[2]

Abstract: Business processes need to follow prescribed regulations. For audits and for following good practices, organizations need to know whether regulations are followed or where and why deviations exist, such that they can manage their processes accordingly. Conformance checking, a key function of process mining, allows to check the relation between a process model and process data collected by IT systems, and to identify as well as analyze deviations between them. At the same time efforts exists to formalize laws, guidelines, and manuals in the computer-interpretable form of so-called reference process models. Hence, conformance checking appears to be a well-suited approach to automatically check whether a business process fulfills certain regulations, but several challenges need to be overcome. In this paper, we review existing research in this area, describe open research challenges, and design a research agenda to combine techniques from reference modeling and conformance checking to compare real-life process behavior with prescribed regulations.

Keywords: Regulations; Reference models; Conformance checking; Event log

1 Introduction

Business processes often have to follow specific prescribed regulations, such as clinical practice guidelines in healthcare, laws and statutes in public administration, or the new hygiene rules in many different domains. For both organizational success and official audits, it is essential to know: Are we following the prescribed regulations? If we deviate, why? Should we improve employees' training or system implementation ? Could the rules be adapted to be better applicable in the real world?

Process mining provides insights into the business process execution and techniques for evidence-based process analysis. Process conformance, a key function of process mining, analyzes the relation between the designed and the recorded behavior of a business process [Ca18]. A process model capturing the intended behavior of a business process as a result of process modeling or process discovery is compared to an event log recorded during the execution of a business process. It reveals overlaps and deviations, such as missing activities, and hence allows organizations to answer the above-raised questions.

[1] Technische Universität Berlin, Software and Business Engineering, Einsteinufer 17, 10587 Berlin, Deutschland
luise.pufahl@tu-berlin.de
[2] Universität Mannheim, Juniorprofessur für Management Analytics, L15 1–6, 68161 Mannheim, Deutschland
rehse@uni-mannheim.de

At the same time, efforts exist to formalize (sufficiently concrete) laws, guidelines, and manuals, such as clinical guidelines [Bo11] or youth welfare rules [Be18], in form of business process models to increase the transparency, decrease ambiguities, and facilitate stakeholders' understanding. We define such models as reference models, i.e., conceptual models that serve to be reused for the design of other conceptual models [FL06]. They are often assumed to be universally applicable to a class of organizations and to exhibit a certain quality, containing either best or common practices for conducting business [FL06]. Laws, guidelines, and manuals can be considered informal reference models, because they are domain-specific, prescriptive, and universally applicable, but they exist in natural text. Thus, they need to be transformed into computer-interpretable reference models.

These two developments make process conformance checking a well-suited approach to automatically check whether a business process fulfills a certain regulations. However, to leverage these potentials, major challenges need to be addressed. In the following, we discuss existing works in Sect. 2, list open research challenges in Sect. 3, and describe our research agenda in Sect. 4.

2 Overview of Existing Research

Compliance Checking. Traditional compliance checking approaches rely on designed business process models (design-time compliance) [AW09]. However, because those models are often outdated or even non-existent [Ly15], compliance checking needs to take process execution data into account. This data enables organizations to check whether a business process follows the regulations by inspecting it on a case-by-case basis, either retrospectively (auditing) or in real time (run-time compliance checking). Although multiple approaches for run-time compliance or auditing exist, the practical application of these techniques still faces serious limitations [Ha18], such as the extraction of formal representations of the norms in an understandable format, the judgement of the deviation's relevance and their handling, and the evolution of business processes. One approach to address those challenges is rule-based compliance checking, which automatically verifies whether process models adhere to a certain set of (regulatory) rules. Although promising, there are many open challenges in the practical management of such rules (within or separate from the process models) [CD20]. Another approach to compliance checking on system execution data is the application of complex event processing techniques [Kr20], which has also already been used for the monitoring of business process execution [Kr14] and could therefore be interesting for business process compliance as well. Overall, compliance checking and conformance checking are closely related. Compliance checking is one application case of conformance checking. Conformance checking is one technique for compliance checking, which has the potential to address the above-mentioned practical challenges of other compliance checking techniques. However, this would need a reliable conformance basis and expressive visualizations.

Conformance Checking with Regulations. In existing research, we can observe that conformance checking with regulations is domain-specific, fragmented, and no general approach exists. Table 1 contains an overview of existing works, along with their domains, regulatory documents, goals, and technical approaches. It shows that conformance checking with regulations is already applied in several domains and that existing work has already identified and targeted different challenges. Those challenges include the consideration of organizational [JAV14] or temporal aspects [STD17] as well as contradicting [PTD18] or cross-referencing regulations [Hu20]. Also, the non-conformance of process executions to a regulation might be necessary or justified, such that positive (i.e., desired) deviations need to be considered [Bo11]. In addition, regulations, corresponding reference models, and process events logs are available in very different granularities, such that currently, it is a manual effort to align the events with the activities in a reference model [GT09].

Domain	Regulation	Source	Goal of conformance checking	Technique
Auditing	Auditing rules	[JAV14]	As a new auditing procedure to detect whether certain rules are fulfilled	Manual approach where specific variants and the interaction between involved staff is checked
Data Privacy Protection	General Data Protection Regulation	[ZH20]	Ascertaining compliance to certain GDPR provisions, mainly related to the data subject rights	Manual approach where a process model in a company is extended by GDPR activities and temporal constraints for using it as input for conformance checking
Healthcare	Clinical guidelines	[STD17]	Checking conformance of temporal rules	Answer set programming
		[Bo11]	Involving basic medical knowledge in addition to the clinical guideline aiming at providing a justification for non-conformances	Formalize Clinical Guidelines and Medical Know-ledge as Event Calculus
		[PTD18]	Explaining non-conformance by considering that multiple clinical guidelines exist	Use the approach in [STD17] and use ontologies to identify inter-actions between clinical guidelines
ITSM	ITIL	[GT09]	Improving the quality of IT processes by comparing their execution to a reference model representing incident management in ITIL	Application of the token-replay in the academic tool ProM, manual bridging of granularity levels in log and reference model

Tab. 1: Overview of research works on conformance checking with regulations in different domains.

Visualization of conformance checking results. State-of-the-art conformance checking methods usually compute an overall fitness or conformance measure between log and model [Ca18]. If more details are required, they compare trace and model, illustrating the deviations per trace [Ca18]. Existing approaches for conformance checking visualization on the trace level were developed to convey research results rather than being optimized for understandability. This is why there is a number of problems with these visualizations that make them difficult to adapt. [Ga17] provide textual representation of behavior deviations to the users, which was perceived as simpler. Still, the authors promote future research in this direction to improve the interpretability of conformance checking results.

3 Open Challenges

Based on the above review of the state-of-the-art, we can summarize the research gap related to conformance checking with regulations by means of three challenges:

Visualization: Conformance checking results need to be visualizedsuch that they provide actual value for business users and allow to initiate actions based on the results. The requirements by non-process expert business users are currently unclear and empirical research on user-friendly visualizations are rare.
Computer-interpretable regulations:. Regulations are only available as extensive and informal documents. However, computer-interpretable (semi-)formal reference process models are needed as input for conformance checking. So far, no general approaches exist for supporting the (deductive) construction of such models.

Generalized Approach:. A generalized approach for conformance checking with regulations is missing. Such an approach should consider, among other aspects, different process dimensions (such as control-flow, timestamps, and organizational aspects), cross-references and contradicting relations between regulations, the opportunity of positive deviations, and the right degree of abstraction between logs and models.

4 Research Agenda

Fig. 1 shows our ideas for a holistic approach for conformance checking with regulations. It is supposed to support business users to improve their daily practice with guidelines and regulations, or to improve existing ones, and to prepare audits, with the following sub-goals:

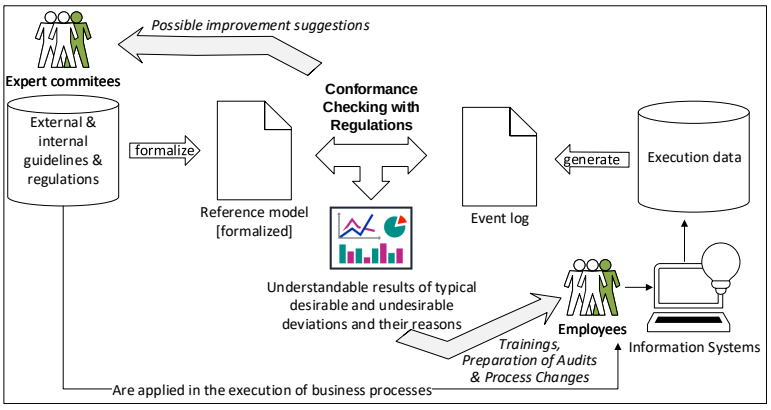

Fig. 1: Overview of the planned approach

Useful representation and visualization of conformance checking results. Guidelines and regulations are usually generated by expert committees to reach a certain process quality or to streamline the process execution. Organizations want to know how they are applying

them, and where improvements in IT systems, or trainings for employees are necessary. Furthermore, some aspects of guidelines/regulations might not be applicable in reality such that a feedback loop into the expert committees is useful. Thus, the objective is to identify business users' needs for representation and visualization to allow actions for handling violations. Furthermore, it should be a goal to develop techniques to ease the representation of conformance checking results for business users and to handle their complexity.

(Semi)-automatic support for deductive reference modeling. Conformance checking with regulations needs as input a (semi-)formalized reference model. Currently, creating such models is still a manual effort. It is the objective to develop a (semi-)automatic technique to formalize a reference model based on a given textual description.

Holistic conformance checking approach with regulations It is the objective to develop a conformance checking approach, which considers the special aspects of regulations, such as different dimensions (including control-flow, temporal, and organizational aspects), or the existence of multiple competing or related regulations. Such an approach should be able to handle non-conformance that might be justified with business knowledge or with specific circumstances in the environment. In addition, event logs need to be available on the abstraction level of the reference model representing the regulation to perform the conformance checking.

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