ARTIFICIAL INTELLIGENCE

University of Ferrara - Enhancing Industry 4.0 with (Probabilistic) Process Mining

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Context of the research activity	An organisation's performance critically depends on the quality and accuracy of its processes, which are therefore a fundamental asset. The area of Business Process Management is devoted to the study of process models: Process Mining is defined as the discipline for discovering, monitoring, and improving business process models. The research tackles the tasks of reasoning and learning declarative process models using probabilistic logic programming, ASP and machine learning techniques, with a special attention to the management of uncertainty.
	The management of business processes is of extreme importance for supporting efficiency improvements in organisations. An organisation's performance critically depends on the quality and accuracy of its processes. Process Mining (PM) stands as a crucial technique in the era of Artificial Intelligence and Industry 4.0, providing transparency and insights into operational processes that are otherwise complex and opaque. In fact, PM is defined as an analytical discipline for discovering, monitoring, and improving business process models. The input data consists of execution traces (logs), and the output can be a process model (discovery), the conformance of the log w.r.t. an existing process model (conformance), or the improvement of a process model (enhancement). Two categories of languages may be employed to represent process models: procedural and declarative. Declarative languages (such as DECLARE) describe process models through constraints on the process execution, while procedural ones specify the sequence of tasks to be executed as paths in a net. If the latter approaches might be too rigid, declarative approaches instead provide a higher level of flexibility. Both declarative and procedural lines of research demonstrate a growing interest in accounting for an uncertainty-related component in logs and process mining tasks. The doctoral research is expected to contribute several innovative solutions to the field: - It will provide a foundational semantics for declarative process modelling, by considering abductive logic-based semantics;

Objectives	- It will provide an operational support for declarative process modelling based on computational logic, where the integrated use of Probabilistic Logic Programming (PLP) and Answer Set Programming (ASP) will allow one to extend the expressive power of the DECLARE language and of the corresponding reasoning and learning tasks; - The outcomes are expected to include a comprehensive set of tools and methodologies that can also be applied in real-world industrial settings, contributing to the advancement of Industry 4.0. The doctoral student will have to address assumptions that are traditionally made in binary declarative PM but do not always hold in real cases: • a process model able to perfectly distinguish between posi-tive and negative examples (binary log) always exists; • noise in the log; • log incompleteness; • understandability of a declarative model might be under-mined by the large number of its constraints. To properly address the issues associated with the above assumptions, knowledge representation languages and their corresponding reasoning and learning techniques will need to be identified and reshaped, with a special attention to the management of uncertainty. The doctoral student will take care of: - extending the DECLARE language to cope with probabilistic knowledge and information; - developing declarative process discovery techniques capable of directly learning probabilistic constraints from an event log and according to the semantics previously defined. These models will help in optimizing resource allocation, or in ad-justing process parameters proactively to avoid quality issues in industry; - redefining the compliance of a set of traces with respect to a model according to the probabilistic semantics, possibly in real time. - employing industrial use cases with large event logs to evalu-ate the developed techniques. Seat of Work: Ferrara For more information, please contact: Evelina Lemma: evelina.lamma@unife.it Elena Bellodi: bllllne2@unife.it
Skills and competencies for the development of the activity	We are looking for a candidate that preferably meets the following profile: - a background in Computer Science Engineering, Artificial Intelligence, Machine Learning; - a strong interest in the topic of Process Mining and Probabilistic Logic Programming; - a strong interest in conducting interdisciplinary research and the ability to effectively cooperate with scientists of various interdisciplinary backgrounds; - strong engineering skills and well-developed programming skills (especially Prolog and Python); - good communicative skills in English, both in writing and speech.