Mining Agent-Based Models of Business Processes: Extended PhD Abstract

Andrei Tour[1]

[1]The University of Melbourne,Carlton, VIC 3053, Australia

Abstract

This Ph.D. project is positioned at the intersection of Business Process Management, Process Mining, and Agent-Based Modeling & Simulation. We hypothesize that applying the agent-based modeling paradigm to process mining can improve the state-of-the-art techniques for producing process models from data. To test this hypothesis, the project addresses the research questions about suitable agent-based ontology and methods for discovering and validating agent-based process models. The research aims to create a framework for mining business processes as agent systems, algorithms for agent system model discovery and validation, and a suitable agent-based ontology.

Keywords

Process Mining, Agent-Based Modeling, Agent System Mining

1. Introduction

The topic of our Ph.D. research is mining agent-based models of business processes. In an organization, business goals are achieved through the execution of business activities. Coordinated sets of these activities are called business processes [1]. Business processes can be executed by human or non-human (computer, robot) actors. Business Process Management (BPM) deals with business process improvements through the design, configuration, enactment, and analysis of business processes. To this end, BPM uses business process models. A business process model (or simply a process model) is a template for a set of business process instances having a similar structure [1].

Process Mining (PM) automates analysis, creation, and update of process models using the business processes information obtained from historical and current event data captured by information systems [2]. Multiple PM activities can be used to perform modeling tasks in different places of a process model lifecycle. PM algorithms automate PM activities from one or more perspectives covering various aspects of business processes, for example, control flow, data, time, organization, and resource aspects. The main PM perspective is the control-flow perspective. It requires every event in a log to have three attributes: timestamp, activity, and case.

Agent-Based Modeling (ABM) is a useful paradigm for modeling and simulating organizations and their processes [3]. In the ABM paradigm, an enterprise can be conceptualized as a Multi-

Doctoral Consortium co-located with 21st International Conference on Business Process Management (BPM 2023), Utrecht, The Netherlands, September 1th to 15th, 2023.

atour@student.unimelb.edu.au (A. Tour)

Agent System (MAS) of networked autonomous technical (computer and robotic) and social (human) agents that interact with each other and their environment to bring about results [4]. Macro-level business processes emerge within a MAS from local micro-level behaviors of agents. This approach does not explicitly define holistic macro-level control flows. Instead, local control flows are defined at the micro-level of separate agent models integrated in one MAS.

A significant body of knowledge exists for modeling business processes in the ABM paradigm and mining global control flow process models as two separate research topics. However, the combined topic of mining agent-based models of business processes is insufficiently researched.

2. Relevance

This section argues for the relevance of this PhD project by providing evidence for the research gap and explaining the benefits of this project.

In 2006, Cabac et al. [5] reported a gap in integrating process mining (PM) with agent-based modeling (ABM), and introduced the Agent Interaction Mining (AIM) approach to support analysis, design, and validation of Multi-Agent Systems (MASs). The AIM approach attempts to close the PM-ABM integration gap from the "PM for ABM" side by bringing existing PM perspectives into the ABM and MAS development contexts. The motivation for our Ph.D. project is to address the PM-ABM integration gap from the other, "ABM for PM", side by bringing an explicit agent-based perspective into the PM context.

The need for an explicit agent-oriented perspective in process mining was indicated by Flick et al. in their positioning paper [6] in 2010. This paper stated that the best way to describe real-world processes in organizations and cross-organizational contexts would be to conceptualize these processes as performed by systems of interacting agents. A study of workflow mining systems [7] noted that the BPM community widely used the MASs approach to research business processes but this approach had never been applied in process mining.

The initial literature review we conducted in 2021 [8] could not find any publication defining an agent-oriented process mining perspective with explicit use of agents and other agent-based modeling concepts for describing discovered business process models. Thus, the PM-ABM integration gap reported earlier still exists. To address this gap, this Ph.D. work introduces Agent System Mining (ASM) as a new process mining perspective with explicit MAS models of business processes. In addition, it describes the ASM framework for research and development of ASM algorithms for automating all stages of the lifecycle for MAS models of business processes.

Conventional PM techniques are based on simplifying assumptions. One such assumption is the existence of a centralized global control flow linking all events related to the same case [9]. Not all real-world business processes have a predefined single control flow. Often, stakeholders find it difficult to relate to a high-level abstraction of a single business process connecting all activities contributing to a business goal [3]. In this situation, using conventional PM techniques based on the single control flow assumption results in process models that have low accuracy and are difficult to visualize and understand due to a large number of model elements and relationships. In the ABM paradigm, there are no macro-level control flows, and organization-wide business processes emerge from the local behaviors of self-organized agents. Following this paradigm, this Ph.D. project aims to relax the single control flow assumption and to define

algorithms for constructing more accurate and simpler agent-based process models.

The new knowledge produced by this research will provide benefits to the PM and BPM communities. For the PM community, this research will introduce the ASM perspective as a new way of thinking about mining business processes from data that can lead to the creation of new agent-based mining algorithms capable of discovering better quality models. For the BPM community, this research will offer new ways to automate the creation of business process models based on the existing agent-based BPM frameworks and will suggest agent-based BPM ontologies suitable for the effective application of PM in the context of agent-based business process modeling and simulation.

3. Questions and Contributions

We hypothesize that applying the agent-based modeling paradigm to mining business processes from event data can improve the state-of-the-art process mining techniques for producing process models in the business process management context. To test this hypothesis, the project addresses the following research questions.

RQ1: What agent-based models of business processes discovered from data are useful?
This question is concerned with methods for validating agent-based models discovered from event data and using these methods to check the usability of the discovered models for intended purposes.

RQ2: How to discover agent-based models of business processes from data?
This question addresses the study of techniques that take a business process event data as input and automatically produce an agent-based model of the business process that can be used for BPM purposes.

RQ3: What ontologies are suitable for agent-based process models discovered from data?
This question addresses the effectiveness of ontologies for specifying agent-based business process models discovered from data. An ABM domain ontology is understood as a set of concepts and categories and the relations between them.

To explore these research questions, our Ph.D. project introduces ASM as a new process mining extension that combines process mining with agent-based modeling to automate the development of agent-based models of business processes. The project aims to produce the following contributions: an ASM framework that defines phases, tasks, activities, and artifacts that are required to develop agent-based models of business processes; an algorithm for automated discovery of executable models of business processes from event logs; a method for validating agent-based models of business processes discovered from data; an ontology suitable for describing agent-based models of business processes discovered from data.

4. Method

This section summarizes the research method used in this Ph.D. project. It follows the Design Science Research in Information Systems (DSRIS) method [10]. First, the details of the research

problem are explicated by reviewing literature related to the outlined research topic, and the requirements for the project research artifacts are specified as per Section 3. Next, the artifacts are developed and evaluated. The process and results of the development and evaluation of these research artifacts will be communicated in the Ph.D. thesis. The datasets used in this project are either synthetically generated using simulation software or sourced from publicly available process data repositories such as the Business Process Intelligence Challenge (BPIC) dataset repository (https://data.4tu.nl/search?q=BPI). The current research plan does not require interviews or surveys of people. This plan may be revisited as the research project progresses and the new need for people interviews is identified.

5. Progress to Date

Here we outline the research activities completed so far in this Ph.D. project.

1. Conceptualization of Agent System Mining (ASM) as an agent-based extension of PM.
2. Identification of PM problems and opportunities addressed by ASM in the BPM Context.
3. Literature review to identify reusable results and gaps for the ASM Framework.
4. Definition of the ASM Framework.
5. Study 1: Agent Miner algorithm for discovery of agent-based Petri net models of business process from event logs.
6. Identification of the research questions based on the ASM framework and Study 1.

The results for items 1 – 4 were published in the ASM paper [8]. The results for item 5 are reported in the Agent Miner paper to be presented at the BPM 2023 conference [11].

6. Plan to Completion

The following are the expected activities to complete this Ph.D. project:

1. Study 2: definition of an approach for assessing usefulness of agent-based models of processes discovered from data;
2. Study 4: specification of an ontology for agent-based models discovered from data;
3. Study 3: design of the Agent Miner algorithm improvement grounded in the ontology from study 3 and assessment of this improvement using the approach defined in study 2;
4. Ph.D. thesis preparation.

The studies specified in items 2, 3, and 4 contribute to the research questions RQ1, RQ3, and RQ2, respectively. Each of these items includes iterative design, implementation, and evaluation of the research artifacts associated with that item. Item 4 communicates the process and results of our Ph.D. work in the Ph.D. thesis document.

7. Conclusion

The ambition of this Ph.D. work is to improve state-of-the-art process mining techniques by introducing an explicit agent-oriented perspective in process mining called Agent System Mining (ASM). ASM bridges Process Mining and Agent-Based Modeling by interpreting business behavior as emerging from the activities and interactions of agents. Under this perspective, the project aims to develop new discovery techniques that produce agent-based models of business behavior and structure. The project will test the hypothesis that agent-based models of business behavior and structure produced by ASM techniques exhibit better quality and bring new insights to business process analysis grounded in the agent-based modeling paradigm.

Several challenges may prevent this project from achieving its goals. First, there may be a lack of publicly available real-world datasets suitable for use in ASM algorithms. This risk can be addressed by using synthetic datasets or engaging with the industry to access private enterprise data. In addition, the traditional model quality frameworks may not be appropriate for adequate assessment of agent-specific benefits of ASM-discovered models. To deal with this limitation, it may be required to define new agent-specific quality measures for evaluating agent-based models of business processes mined from event data.

References

[1] M. Weske, Business Process Management - Concepts, Languages, Architectures, Third Edition, Springer, 2019.

[2] W. van der Aalst, Process Mining: The Missing Link, in: Process Mining: Data Science in Action, Springer, 2016, pp. 25–52.

[3] E. Bonabeau, Agent-based modeling: Methods and techniques for simulating human systems, Proceedings of the National Academy of Sciences 99 (2002) 7280–7287.

[4] M. Seck, J. Barjis, An Agent Based Approach for Simulating DEMO Enterprise Models, Procedia Computer Science 61 (2015) 246–253.

[5] L. Cabac, N. Knaak, D. Moldt, H. Rölke, Analysis of multi-agent interactions with process mining techniques, in: MATES 2006, volume 4196 of *LNCS*, Springer, 2006, pp. 12–23.

[6] N. E. Flick, L. Cabac, N. Denz, D. Moldt, Re-thinking process mining with agents in mind, in: AWPN, volume 643 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2010, pp. 94–99.

[7] M. Abdelkafi, D. Bousabeh, L. Bouzguenda, F. Gargouri, A comparative study of workflow mining systems, in: 2012 6th International Conference on SETIT, 2012, pp. 939–945.

[8] A. Tour, A. Polyvyanyy, A. Kalenkova, Agent system mining: Vision, benefits, and challenges, IEEE Access 9 (2021) 99480–99494.

[9] W. van der Aalst, Getting the data, in: Process Mining: Data Science in Action, Springer, 2016, pp. 125–162.

[10] A. R. Hevner, S. T. March, J. Park, S. Ram, Design science in information systems research, MIS Q. 28 (2004) 75–105.

[11] A. Tour, A. Polyvyanyy, A. Kalenkova, A. Senderovich, Agent Miner: an algorithm for discovering agent systems from event data, in: BPM 2023, LNCS, Springer, 2023.