Synthesis of Strategies for Robotic Process Automation

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Abstract. Robotic Process Automation (RPA) is an umbrella term for tools that run on an end user's computer, emulating tasks previously executed through a user interface by means of a *software robot*. Nowadays, only simple, predictable tasks can be automated in situations where there is no room for interpretation, while more sophisticated work is still left to human experts. The here proposed research aims at tackling this issue through a paradigm shift in conceiving software robots that are able to behave intelligently and flexibly in many dynamic and knowledge-intensive situations that are common in today's application scenarios.

Keywords: Robotic Process Automation · Human Computer Interaction · Process Mining · Automated Planning

1 Summary of proposal

A today's recurrent question is "*What should be automated and what should be done by humans*?" [2]. The recent developments in Artificial Intelligence (AI) force us to revisit this question continuously. RPA [10] is one of these developments based on the notion of *software robot*. The robot is developed to capture the execution of the tasks previously performed by a human user on the UI of a computer system, and then to emulate the automation of such tasks in place of the user. To date, software robots are manually developed by a human designer through a *trial-and-error* approach, which consists of designing a *flowchart diagram* that determines the *behaviour* of the robot and of verifying its ability to properly mimic the flow of user's actions required to execute a task on the UI [9]. Instead of manually pre-defining the behaviour of a robot, the target of this research is on leveraging a combined use of techniques from the fields of Human-Computer Interaction [5], Process Mining [1], and Automated Planning in AI [7] for: *(i) identifying* and *interpreting* the robot's behaviour by looking at the *interaction logs* that record the concrete user actions taking place during a run of the system; *(ii)* automatically *discovering* the flowchart diagram that describes all possible behaviours of a robot; and *(iii) orchestrating* the behaviours of single robots in order to synthesize complex *execution strategies* able to emulate the enactment not just of single tasks, but of interconnected and large workflows.

2 State of the art

Most of the actual deployments of RPA are industry-specific, e.g., financial and business services [2], and the market for RPA solutions is developing rapidly. Nowadays, robots are mainly used for automating repetitive office tasks in operations like accounting, billing and customer service. Robots are capable of log into applications, connect to system APIs, copy and paste data, extract semi-structured data from documents, read and write to databases, open e-mail and attachments, fill in forms, make calculations, etc. Despite the capabilities of software robots, the RPA technology is still in its infancy, even if similar solutions have been around for a long time. For instance, closely related to software robots, *chatbots* have been using for years to accept voice-based or keyboard inputs and guide customers to find relevant information in web-based applications [8]. Differently from chatbots, RPA can be seen as an evolution of traditional *screen scraping* solutions [4], which sought to visualize screen display data from legacy applications (having no means for automated interfacing) in order to display such data using modern UIs. The strength of RPA is that it does not replace existing applications or manipulate their code, but rather works with them in a way similar to a human user. However, it is worth to notice that the current generation of software robots is guided by procedural rules rather than AI. To be more specific, a software robot can be developed by a human designer through a *trial-and-error* approach consisting of 2 steps that are repeated until success [9]:

- First, the designer produces a *flowchart diagram* that includes the single actions to be performed by the robot on the UI to emulate a task of the system.
- Second, the designer checks if the robot's behaviour during the execution of the task on the UI is capable to properly reproduce the behaviour of a human user that executes the same task. If any misalignment exists, the designer adjusts the flowchart diagram to fix the identified gap.

While this approach is particularly effective for executing simple rules-based logic in situations where there is no room for interpretation, it becomes time-consuming and error-prone in presence of tasks that are less predictable or require some level of human judgment. As a consequence, RPA is not yet able to fully replace human work. Only simple, predictable tasks can be automated. In cases where the rule set does not contain a suitable response for a specific situation, robots allow for escalation to a human supervisor . This is particularly true in today's application scenarios, where also predictable tasks become less-predictable, due to the huge amount of data and events produced in these contexts that may influence their enactment.

3 Research objectives and methodology

This research falls within the scope of RPA, and its overall objective is to devise an approach to automatically synthesize intelligent execution strategies for enacting software robots in dynamic and knowledge-intensive situations, without the need of manually pre-defining the behaviours of such robots. Fig.1 shows an overview of the *three-steps approach* described in Section 1, for achieving the aforementioned objective.

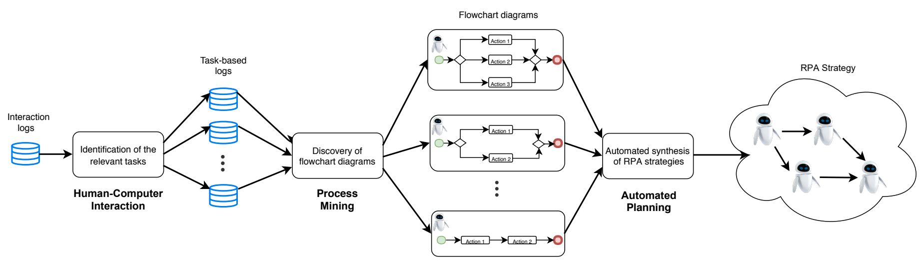

Fig. 1. Approach overview

Objective 1: Identify the relevant tasks to be emulated through software robots by looking at the interaction logs that keep track of the user actions taking place during a run of the system.
Methodology: Development of a novel method in HCI [6] to analyse interaction logs for: *(i)* understanding which user actions have to be captured; *(ii)* interpreting their semantics (also) on the basis of their granularity and *(iii)* identifying the boundaries of relevant tasks. As a result, the list of user actions associated to a complete execution of a relevant task during a run of the system will be recorded into specific execution *traces*. Then, all the traces associated to a relevant task will be clustered in a *task-based log*.

Objective 2: Once identified the relevant tasks to be emulated and the user actions that constitute them (i.e., the task-based logs), the target will be to automatically generate the flowchart diagrams describing the behaviours of software robots required to successfully executing a systems relevant task.
Methodology: Identify which state-of-the-art algorithms suit better to extract the base structure of flowchart diagrams from a task-based log by resorting on discovery algorithms from the Process Mining [1] field, and also on trace alignment [3] techniques.

Objective 3: Automated synthesis of RPA strategies starting from the flowchart diagrams discovered from the task-based logs.
Methodology: The idea is to leverage automated planning techniques in AI [7] for the synthesis of complex execution strategies, in order to emulate the enactment not just of single tasks but of interconnected and large workflows as the composition of many relevant tasks of interest.

4 Results, impacts and benefits

The major results that will be obtained by achieving the objectives of this research are: the *(i) automated identification of relevant tasks*, the *(ii) automated generation of robots' behaviour* and the *(iii) automated synthesis of RPA strategies*. Apart from the ability of automatically generating robots' behaviour and complex strategies of execution for robots starting just from an interaction log, this research proposal aim at also improving the *auditability* (interaction logs are auditable), *upgradability* (flowchart diagrams describing robots' behaviour will be always updated to the current state of system's execution, by employing trace alignment techniques) and the *resiliency* (the ability of having software robots that are always upgraded to deal with new behaviours make them very robust and resilient to any contextual change that may arise during a task execution) of software robots. Furthermore, *scalability* will be improved as well. Human capacity is difficult to scale in situations where demand fluctuates, instead software robots operate at whatever speed is demanded by the work volume. Finally, we also envision that the proposed research will provide long-term benefits on the companies workforce, e.g., improving the customer service in the front office while at the same time reducing the back office tasks. Last but not least, the synthesis of RPA strategies will allow multiple robots to be deployed when demand exceeds the capacity of a single robot increasing the overall productivity.

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