Informing Robotic Process Automation (RPA) by Analysing Human Users' Problem-solving Strategies

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Abstract

Robotic Process Automation (RPA) has emerged as an important topic for the industry and for the scientific literature, given its great potential to reduce the costs and to increase the efficacy of business processes. RPA tools are generally developed as rule-based system which mimic the actions of a human users on a software interface in order to automate repetitive, well-defined tasks. Because these solutions follow the same exact steps, they might be less flexible to changes in the interface or the task specifications. Artificial intelligence might overcome some limitations but has its disadvantages. In this paper, we argue that cognitive models inspired from the ways in which human users perform a business task might represent a sound basis to define flexible and efficient RPA solutions. We propose the think aloud protocol as an adequate methodology to develop such cognitive models and we exemplify how this methodology can be applied.

Keywords: Robotic Process Automation (RPA), Think Aloud Protocol, Problem-solving, Cognitive Model

1. Introduction

Using software robots to automate business-related processes is one of the "hot topics" in both industry and academic research [1, 2]. Robotic Process Automation (RPA) is the general framework for developing such software robots and has been implemented in a variety of business sectors (e.g., banking, insurance, healthcare) and for a variety of tasks (e.g., processing invoices, automated reports) [3]. RPA is a solution that is used to automate repetitive tasks defined by business rules across one or several business applications [4]. RPA is a flexible methodology, different from "classic" business automation, which implies hardcoding business processes in a dedicated software solution. Instead, RPA can copy the ways in which a human user interacts with multiple software interfaces and performs the same tasks automatically, following a set of pre-specified rules. The tasks that are best fitted for RPA are those that have a medium to high frequency in an employee's daily activity. Very high frequency tasks are better automated by hardcoding, while tasks with low frequency are left to be handled directly by the human user [5]. Many customer/service desk activities that are sometimes outsourced to specialised service providers are good targets for RPA solutions [6].

Although most of RPA solutions might integrate different artificial intelligence solutions to perform sub-tasks (e.g., optical character recognition – OCR – to extract information from a scanned document), the general sequence of steps to be performed is rule-based as defined by the RPA architect. Process mining has been explored as a smart and effective way of developing RPA routines [7]. Processes automated based on business rules will have difficulties in handling the smallest exceptions and might be easily affected by any changes in the interfaces of the applications that are being used to perform the task. Artificial intelligence and machine learning can be employed to develop a more flexible model of the process, based on the logs of the users' activity, but such a solution might generate additional complexity in the automation process and

might still lack some flexibility when changing the applications and the interfaces involved in the process. To overcome such issues, we propose an additional design philosophy involving a high-level cognitive description of the business process to be automated based on the analysis of the users' thinking patterns.

This is not a completely new idea. Cognitive models derived from the psychological analysis of the human problem-solving process have been previously prosed as a solution to the many challenges raised by automatic software testing. Scholars suggest that the test design and execution can be viewed as a problem-solving process [8]. Problem-solving has been viewed in psychology research as being determined by representation and search processes [9]. In this way, a problem is represented as a problem space, consisting of states and operators. A human solves a problem when it finds a path from the initial state to the goal state. In order to solve testing problems, one would need to use several cognitive processes such as knowledge, skills, creativity and other cognitive resources involved in the processing. According to the cognitive model of software testing [10], human testers follow certain stages in their process of problem-solving: establish the goal of the testing process, identify relevant knowledge for the current test scenario and organize it in a meaningful way, develop a strategy on how to achieve the goal, allocate mental and physical resources to implement the task, monitor the progress, and conduct an evaluation to check if the goal has been achieved. Although the actual steps of different business process that are desired to be automated might be very different from the automation of software testing, we believe that this general cognitive/psychological framework of analysis can be applied to almost any business process and can generate a model that might inform the RPA architect in ways that other design philosophies can't.

By analogy, we can think of any business process performed by a human as a problem-solving task, requiring some input and having an end goal. The human must use her knowledge and skills to find a way from the current state to the desired output. If these components are cognitively penetrable, we could identify them, develop a model of the problem-solving process, and make it automatic using RPA. To do so however, one would need a very accurate description of the problem-solving process takin place in the mind of the human user. The think aloud protocol is a method developed by cognitive scientists to achieve such a goal. This method consists in asking subjects to think aloud as they go about solving any kind of problem and offering detailed descriptions of all the involved steps [11]. The think aloud protocol has been previously used in software testing research to generate cognitive models about how testers develop their input data [10].

2. Objective

Our work has three main objectives. The first one is to demonstrate how the think aloud protocol can be used to identify the problem-solving process undertaken by a human user interacting with a software interface, with the goal of completing a business-related task. The second objective is to illustrate how the description of the problem-solving process can be translated in a cognitive model of the task. Finally, the third objective is to illustrate how the cognitive model can then be translated in an RPA version of the same task and analyse the strongpoints and the weakness of this RPA design approach. We expect that an RPA solution that mimics human problem-solving will have good flexibility in accommodating changes in the interfaces of the software applications or the tasks' specifications.

This work is relevant to the Methodologies and Education tack of the 30th International Conference on Information Systems Development (ISD2022) as it presents an alternative method to understand the interaction between user's knowledge and the information that the user interacts with trough different software application. Understanding this interplay through a cognitive perspective that can be used to model the processes involved and replicate them in the form of effective and generic RPA solutions.

3. Methods

3.1. Think Aloud Protocol

This will be an empirical study that will collect think aloud protocols of a simple business task. The protocols will be used as the basis to generate a cognitive model and an RPA implementation of the task. More specifically, participants in the study will be required to attend

an experimental session in which they will have to create a Microsoft Teams channel on a specific team group, schedule a meeting on the channel they created, and invite key persons to that meeting. During the task they will be asked to speak aloud their thoughts, including the knowledge there are using to implement de task and the reason behind performing every action. The session will be moderated by a trained psychologist which will introduce participants to the protocol and will ask additional questions every time participant performs an action without verbalising the reasoning behind that action or stops speaking out loud her or his thoughts. The methodology of the study was developed in accordance with the best practices in the field [11]. The session will be video and audio recorded, including the computer screen of the user, and later transformed in a detailed transcript of the user's thoughts.

3.2. Participants

The study will include at least 15 think aloud protocols from different users with various levels of experience in using the application. Participants will be recruited from the academic community in a medium sized city in Romania. The study protocol follows the ethical guidelines for conducting studies with human subjects.

3.3. Data Analysis

We will perform qualitative analysis of the think aloud transcripts identifying the sequence of actions in the problem-solving process, the rationale for each action, the knowledge required to perform it, and the input that is deemed as relevant. We will particularly focus on the minimum elements that are necessary to perform a particular action and achieve the task goals. Based on the individual protocols, we will develop a detailed description of a single problem-solving process that accommodates as many protocols as possible. Special attention will be given to the exceptions that do not fall under the common approach.

4. Expected Results

The results will be presented in a coherent model of the minimum logical steps performed by the users to solve the task, the goal of each step, the minimum knowledge, and other cognitive operations necessary to perform it. A tentative cognitive model is depicted in Figure 1. The poster presented during the conference will include a preliminary model based on partial data. We expect that this approach will offer new insights on how to develop flexible and efficient RPA solutions that could achieve relevant business goals. New tasks with different and more complex business goals will be approached in future iterations of the experiment.

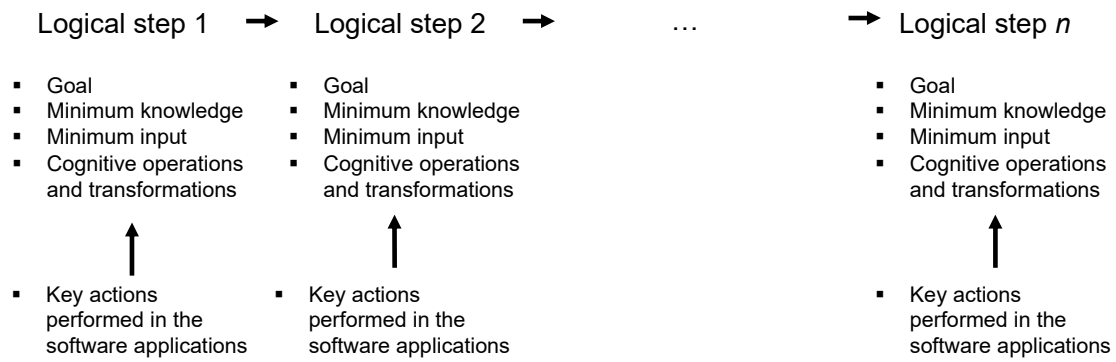

Fig. 1. A tentative structure of the cognitive model for the problem-solving process.

5. Conclusion

Using think aloud protocol to model the problem-solving process through which users complete different business tasks might prove a useful methodology to inspire the development of flexible RPA solutions. Research on software testing has pointed its potential but more empirical research is needed to prove that it can be the basis for RPA design. We propose such an empirical study that can offer support for using this methodology. The proposed study is not without limitations. First, the mapping of the cognitive processes that the user engages in is largely dependent on the accessibility of these processes. Some of them might be implicit and

cannot be verbalized by the participants. It might also escape to the post-experiment analysis of the transcripts. The knowledge and processes used by the human subjects might be task specific and what is learned in one specific task cannot be transferred to other tasks, even slightly different. This might indeed limit the utility of the method that we are advancing. Finally, the strategies that the users make use of might be very heterogenous which will represent a challenge for the development of a coherent and useful cognitive model.

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