IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

HOW RPA AGENTS LEARN

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Abstract: Robotic process automation (RPA) encompasses the automation of processes with the help of software robots. Assisted learning involves human participation, using methods such as human-computer-interaction analysis and natural language processing (NLP) for the development of RPA agents. Unassisted learning is based on reinforcement learning, which offers adaptability but struggles with maturity issues. On the path from RPA to intelligent process automation (IPA), where processes are automatically identified and robots designed, NLP-transformers show a lot of potential. IPA is aimed at recognizing process changes and handling non-routine tasks and shows efficiency improvement capabilities.

I. INTRODUCTION

Robotic Process Automation (RPA) is **software automation** ranging from a simple set of cronjobs to a system of sophisticated self-learning entities embedded typically **on top of the existing software systems**. RPA can be understood as an *". . . umbrella term for a broad range of concepts that enable processes to be executed automatically using software robots that handle existing application systems."* (Czarnecki and Fettke, 2021, p. 12). One must distinguish between RPA-bot (agent) and RPA-system. An RPA bot is a *". . . single instance of an RPS-system that automates a concrete process..."* (Czarnecki, C., & Fettke, 2021, p. 12). An RPA-system is a composition of RPA-bots or even RPA-subsystems. A bot can be seen as an employee doing a task. An RPA system can be seen as one or more employees doing a set of tasks. So, RPA can be used either for support or rationalization.

We distinguish between assisted and unassisted learning. In the former, a human is always involved in the learning process (cf. Rizk et al. 2021, p. 159).

II. ASSISTED LEARNING AND HOW AGENTS LEARN (STATUS QUO)

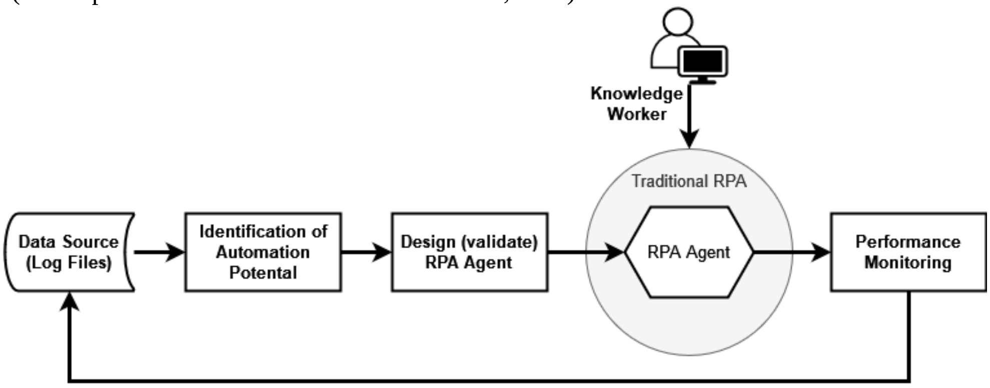
The creation of an RPA agent essentially follows the same process as the development of software. Analysis, design, development, operation, and maintenance, as well as further development. The design and development of an RPA agent is usually done by a human programmer. A crucial question (in the analysis) is which processes are suitable to be taken over by an RPA agent. In practice, manual methods are often used to obtain the exact process by looking at process descriptions or interviewing process experts. With somewhat more complex processes, however, the problem arises that important elements are not documented, something is overlooked or incorrectly formulated. Instead, a human computer interaction (HCI) analysis can be performed (cf. Ramírez et al, 2021, p. 173). For this purpose, user interface (UI) protocols are frequently examined, from which the process can be derived based on human actions. UI logs are records of all actions performed by a user over time. To be more precise, a timestamp with actions performed, such as mouse click, keystroke, etc. Often screenshots are needed as well because switching applications is not uncommon. Ramírez et al., 2021 has shown that the HCI analysis can find more relevant process variants than the conventional analysis. However, it is challenging as people work not only on single processes one after another, but on several processes at the same time. In addition, people make mistakes or do irrelevant things such as watching YouTube videos. Extracting individual process components (which belong together) e.g. from UI logs is called "segmentation" (cf. Agostinelli et. al. 2021, p. 201). In this procedure, processes that overlap are separated from each other. This means that the preceding HCI analysis provides information about **which process is suitable** for RPA and **information about the process flow**. This information must then be translated into an automation routine **by a human programmer, an intelligent algorithm,** or by a combination of both.

There are several approaches to further analyzing UI logs to extract additional information. One of them comes from the field of process mining (cf. van der Aalst, 2021, p. 223). This involves aggregating and correlating UI log information to create event logs that can map or monitor individual processes or systems. Another approach is the use of Natural Language Processing (NLP). By this technique, machine learning algorithms are used to extract information from text documents that describe processes – or even from UI logs. The problem, however, is that such documents must be available (in their current version).

With the present state of the art, a human programmer is required for design, development, and maintenance (cf. Rizk et al., 2021, p. 160; Ramírez et al., 2021, p. 180; cf. van der Aa and Leopold, 2021, p. 194). Human intervention is required because **current RPA methods are less dynamic** and do not automatically adjust if processes change (cf. Selway et al., 2015). They neither learn without human initialization of the learning process nor design themselves. **This is the status quo for most of the traditional RPA applications in practice**. However, some approaches attempt to address these weaknesses.

Intelligent Process Automation (IPA) approaches, in addition to extracting the process, also try to automate the design generation of the RPA agent using NLP algorithms – thus, they coach the learning process. One of these approaches is called text-to-model transformation where a text is translated into an RPA model. The idea is even to go a step further to learn more complex non-routine tasks by making the RPA-system more dynamic. One can say that it is about a meta-learning algorithm to optimize the composition, automation, and collaboration of the bots (cf. Devlin et al., 2018, p. 6).

Figure: IPA and RPA (own representation based on Chakraborti et al., 2020)



According to Chakraborti et al., 2020 we are at an inflection point between RPA and IPA. Nevertheless, approaches that generate the design automatically are currently rather heuristic in nature and lead to errors when text complexity is high (cf. van der Aa and Leopold, 2021, pp. 191-198).

In summary for assisted learning, the difficulty is to **partition human behavior into clear, lean process structures**. The agent does not act independently but is supported with the help of partly intelligent methods such as NLP or process mining (or both). *"Human- in-the-loop RPA training is very common, but it generates RPAs that do not generalize well because they learn in highly specific environments."* (Rizk et al, 2021, p. 159). The problem is not only the "poor" generalization but also the **lack of flexibility** of the agent. If processes change, the RPA agent will not automatically realize it. This is where unassisted learning comes into play.

III. Unassisted Learning and How Agents Learn (Status Quo)

Unassisted learning relies on reinforcement learning approaches, using rewards or punishments to let the RPA agent learn in a **defined environment with predefined rules**. They rely on feedback from the environment and/or other agents (cf. Rizk et al p. 157). Unassisted learning approaches could even enable RPA to not only find and automate processes but also detect and adapt **process changes** (cf. Czarnecki and Fettke, 2021, p. 10). They generalize better than the assisted approaches (cf. Rizk et al., 2021, p. 159).

However, these algorithms are often not mature enough for practical use (cf. Seyd et al., 2020; Chakraborti et al., 2006). This is especially so in critical steps where errors involve risks of various kinds. At this point, according to a survey by Ivančić et al. 2019 p. 9, the literature shows mixed views.

In summary, NLP-based dynamic IPA approaches or unassisted approaches without human- in-the-loop can theoretically be used for automated learning. The RPA agent can be coached by automatic adjustments to process changes.

IV. Future Outlook and How Agents Improve Learning Processes

Currently, **most** of the **RPA applications** are **assisted by human involvement** – except for some research projects. In this context, it is often not meaningful to call it learning. The areas where intelligent algorithms are used have their weaknesses, as described above. According to Devlin et al., 2018 a promising field of research are NLP-transformers. Transformers can process very long sequences of words by using the concept of "attention" (cf. Vaswani et al., 2017, p. 3). For ordinary "Recurrent Neural Networks", the performance decreases significantly at a certain length of a word sequence. The better the analysis of human behavior the better the automated learning process. Moreover, unassisted learning is an emerging research area where processes could be discovered without human-in-the-loop. Not only for RPA but also in other related domains there is a lot of scientific activity. The results of other research areas can be adopted for RPA applications, as was the case for NLP.

At present, there is a discernible trend in the evolution of development, transitioning **from RPA towards IPA**. On the one hand, the idea behind IPA is to **recognize process changes** and on the other hand, IPA should be able to **handle complex non-routine tasks** (cf. Devlin et al., 2018, p. 7). Therefore, the focus is currently on the refinement of the NLP methods used and on the automation of the composition, coordination, and collaboration of agents (cf. Devlin et al., 2018, p. 6).

RPA is not a niche area of research but a field in which it is worthwhile to conduct research on a large scale due to considerable efficiency gains for organizations.

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