An Integrated Approach Using Robotic Process Automation and Artificial Intelligence as Disruptive Technology for Digital Transformation

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Abstract. Digital transformation is a phenomenon arising from social, behavioral and habitual changes due to global economic and technological development. Its main characteristic is adopting disruptive digital technologies by organizations to transform their capabilities, structures, processes and business model components. One of the disruptive digital technologies used in organizations' digital transformation process is Robotic Process Automation. However, the use of Robotic Process Automation is limited by several constraints that affect its reliability and increase the cost. Artificial Intelligence techniques can improve some of these constraints. The use of Robotic Process Automation combined with Artificial Intelligence capabilities is called Hyperautomation. However, there is a lack of solutions that successfully integrate both technologies in the context of digital transformation. This work proposes an integrated approach using Robotic Process Automation and Artificial Intelligence as disruptive Hyperautomation technology for digital transformation.

Keywords: Robotic Process Automation, Artificial Intelligence, Digital Transformation, Hyperautomation.

1 Introduction

Digital Transformation (DX) is a phenomenon arising from social, behavioral and habitual changes as a result of global economic and technological development [1], [2]. Nadkarni and Prügl [3] argue that digital transformation consists of the *"adoption of* *disruptive digital technologies on the one side and actor-guided organizational transformation of capabilities, structures, processes and business model components on the other side"* [3, p. 236].

In this sense, Ribeiro et al. [4], Bu et al. [5], and Daptardar [6] claim that Robotic Processes Automation (RPA) is an excellent tool for innovation and disruptive technology that enable digital transformation in organizations. There are many advantages to implementing RPA in an organization embedded in a DX process. Daptardar [6] argues that *"RPA gets organizations past the halfway point. It permits the organization to mechanize undertakings without waiting to finish each change. When done appropriately, RPA can help departments of the organization gain interval ground while hanging tight for their chance on the need list"* [6, p. 889].

However, RPA has some constraints. Complex workflows, processes with many exceptions, immature systems and unstable environments which require workflow changes are not recommended for RPA applications [7], [8], [9]. Nevertheless, to deal with RPA constraints, various authors propose an integrated approach between RPA and others research topics such as Business Process Management (BPM) [10], [11] and Artificial Intelligence (AI) [12], [8], [13].

However, some authors, such as Daptardar [6] and Hartmann [14], claim that RPA/AI solutions are still in the early stages of their evolution. Only a few large companies use such a solution in their DX processes. One of the reasons the authors give is that automated robots are often limited in changes and new developments, which leads to reduced flexibility and is more error-prone. In addition, there is a lack of solutions that successfully integrate both technologies in the context of digital transformation [6], [8], [12], [13], [14].

Therefore, this work proposes an integrated approach using RPA and AI as disruptive Hyperautomation technology for digital transformation. As a result, we hope to pave the way for enabling the adaptability of RPA to handle changes, making it less error-prone and, consequently, reducing maintenance efforts and costs.

In order to do that, in the following sections, we will describe the problem statement (section 2) and discuss the theoretical background on DX, RPA, AI and Hyperautomation (section 3). After that, in section 4, we will describe the proposed solution. Finally, in section 5, we will point out some final considerations.

2 Problem Statement

According to Siderska [7], RPA is at the forefront of organizations' digital transformation process. Bu et al. [5] claim that RPA is an excellent tool for innovation and disruptive technology that enable digital organizational transformation. In addition, Turcu and Turcu [15] also state that RPA is essential in adequately shifting human resources functions for organizations' digital transformation processes.

Indeed, currently, several business processes, when executed, have activities that can be performed by pieces of software called bots automatically without the need for direct human interference. RPA replaces human actions performed in Graphical User Interfaces (GUI) when performing a specific task in a business process by a software (bot) that imitates them [10].

There are many advantages to implementing RPA in an organization. Ribeiro et al. [4], Siderska [7], and Madakam et al. [16], for example, claim that RPA increases the ability of employees to deal with more work processes, reduces errors in data analysis in order to provide a more assertive decision-making process, reduces the performance of repetition activities by employees, which encourages a focus on more creative work and problem solving, promotes the standardization of processes, which increases the quality of services and products, reduces costs and brings more reliability to the production chain.

However, automated robots are often limited to deal with changes and new developments, which leads to them having reduced flexibility and makes them more error-prone. Nevertheless, workflow changes and software updates are becoming increasingly common due to the dynamic environment in which these solutions work. Moreover, the cost of implementing and maintaining RPA is high [4], [7], [8], [10]. As a result, despite of be an excellent tool for innovation and disruptive technology that enables digital transformation in organizations, RPA has not been a widely used approach in organizations' DX processes [6], [14], [17]. Hartmann [14] claims that *"many things are already feasible today with RPA and AI, although AI, in particular, is still in the early stages of its evolution. Nevertheless, only a few companies are relying on digital transformation. The deployment of one or both technologies can be described as early adopters. This applies specifically to larger companies with sufficient financial resources and human capital and the possibility of coping with setbacks easier"* [14, p. 54]. **Fig. 1** illustrates this scenario.

Several authors propose solutions using AI and RPA together to solve that problem. Yatskiv et al. [12] claim that *"the best way to overcome the mentioned challenge is to apply RPA together with other innovative solutions such as Machine Learning"* [12, p. 502]. Nakano [13] claims that *"in this process of interconnectedness, Artificial Intelligence (AI) and Robot Process Automation (RPA) are disruptive and promise emerging technologies"* [13, p. 51]. In addition, Hartmann [14] claims that *"whereas the areas of application for RPA are rather limited to repetitive, non-complex tasks, AI can cover a broader spectrum"* [14, p. 52]. Bornet et al. [18] go further and claim that RPA/IA solutions can provide a new renaissance for our society, making it more human and reinventing what we call "work". That is what the authors call "Intelligent Process Automation" or "Hyperautomation". However, these approaches were developed to solve a specific problem in a specific context. There is a lack of solutions that successfully integrate both technologies (AI and RPA) in the context of digital transformation.

Thereby, considering what has been discussed so far, we have then summarized our Research Problem (RP):

- RPA has not been widely used in organizations' DX processes due to its constraints in dealing with changes and new developments.

Thus, our Research Question (RQ) can then be summarized:

- How can we leverage RPA as a widely used approach in organizations' DX processes?

With the basis of our research questions and research problem, we summarized our research goal (RG):

- Defining an integrated approach using RPA and AI improves RPA's adaptability to handle changes and makes it less error-prone.

As part of the research goals, we can then summarize three hypotheses (H):

- The hypothesis (H1) is that AI techniques enables RPA solutions to learn from changes.
- The hypothesis (H2) is that AI solutions can be integrated into RPA solutions.
- The hypothesis (H3) is that an integrated approach using RPA and AI can leverage RPA as a digital disruption technology widely used in organizations' DX processes.

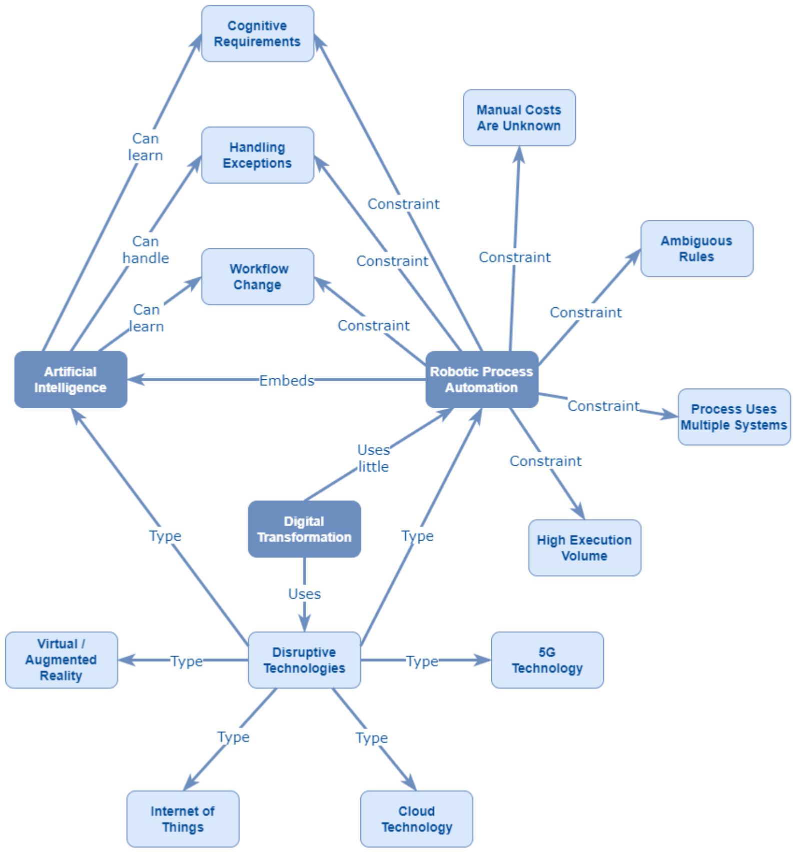

Fig. 1. Conceptual map of the problem statement.

3 Background

3.1 Introduction

In this section, we will discuss the main topics related to this research: Digital Transformation (DX), Robotic Process Automation (RPA), Artificial Intelligence (AI), and Hyperautomation.

The primary purpose of this section is to present the concepts and the main characteristics of the topics mentioned above, as well as to share the results of other studies closely related to what is being carried out. This section aims to establish the importance of the study and works as a benchmark for comparing the results with other findings [19].

3.2 Digital Transformation

Nowadays, the term Digital Transformation (DX) is in evidence. According to Hess et al. [1], DX is the transformation *“concerned with the changes digital technologies can bring about in a company's business model, … products or organizational structures"* [1, p. 124]. In this context, we are concerned about how new digital technologies and business models associated with them impact the existing business models and the value propositions of goods and services. According to Silva Neto and Chiarini [2], *"digital platforms have emerged as a new technical and organizational element capable of changing the dynamics of consolidated socioeconomic models"* [2, p. 1]. In this sense, we are dealing with the change in the dynamics of the customer-supplier relationship phenomena. Moreover, society is experiencing new ways of consuming, buying, communicating, and offering products and services. That is, organizations are experiencing a multidimensional transformation [1].

Hess et al. [1] claim that these changes are not limited to "products, business processes, sales channels or supply chains, but all business models are being reformulated and often overturned". It is about the disruption of business models caused by the impact and effect of new digital technologies, as presented in Udovita [19].

According to Bradley et al. [20], digital disruption *“is the effect of digital technologies and business models on a company’s current value proposition and its resulting market position"* [20, p. 1]. The authors claim that digital disruption can change an organization's business models faster than any force in history and reshape the market.

In this way, Nadkarni and Prügl [21] conceptualize digital transformation in the context of adopting disruptive digital technologies by organizations but also consider an organizational transformation of capabilities, structures, processes, and business approach. One of these disruptive technologies used in the organizations’ DX processes is RPA.

RPA is becoming an essential element of organizations’ business operations. According to Bu et al. [5], RPA is an excellent tool for innovation and disruptive technology that enable digital transformation in organizations. The authors claim that *“RPA has a wide range of applications in various industries such as healthcare and pharmaceuticals, financial services, outsourcing, retail, telecommunications, energy and utilities, real estate, and fast-moving consumer goods”* [5, p. 30]. In addition, Turcu and Turcu [15] also state that RPA is essential in adequately shifting human resources functions for organizations’ digital transformation processes.

3.3 Robotic Process Automation

Currently, RPA is an emerging technology when it comes to business process automation. It is about replacing human actions performed in Graphical User Interfaces (GUI) when performing a specific task in a business process or workflow by a software (robot) that imitates them. In this context, due to the rapid advance of digital transformation in organizations, the digitisation of business processes is increasing evidence. This fact has positioned technologies such as RPA at the forefront of organizations' DX process [7].

There are many advantages to implementing RPA in an organization. According to Siderska [7] and Madakam et al. [16], RPA:

- increases the ability of employees to deal with more work processes;
- reduces errors in data analysis in order to provide a more assertive decision-making process;
- reduces the performance of repetition activities by employees, which encourages a focus on more creative work and problem-solving;
- promotes the standardization of processes, which increases the quality of services and products;
- reduces costs and brings more reliability to the production chain;
- follows regulatory compliance rules and provides an audit trail history.

However, RPA has some constraints. Complex workflows and processes with many exceptions are not recommended for RPA applications. Siderska [7] presents some criteria to identify suitable processes for RPA, such as processes with low cognitive requirements; processes with no need to access multiple systems, given that RPA is applied to existing applications; processes and tasks that are performed relatively frequently. Kaarnijoki [8] also proposed a set of criteria to identify suitable processes for RPA. **Table 1** shows these criteria.

Table 1. Criteria for RPA.

Criteria	Description
High volume	The process has a high volume of transactions or is performed frequently.
The process uses multiple systems.	The process involves accessing multiple systems that otherwise could not be easily integrated
Stable environment	Mature systems and environments remain the same every time process is executed
The process can be broken down into unambiguous rules	The process can be broken down into exact step-by-step rules which have no room for misinterpretation
Minimum need for exception handling	A highly standardised process with little need for handling exceptions
Manual costs are known	The cost structure of the current process is known, and ROI can be calculated for the RPA solution.

Low cognitive requirements	The process does not require judgement or complex interpretation skills.

Furthermore, van der Aalst et al. [9] present a graphical representation to understand the relevance of RPA and to identify the suitable processes considering the proposed by Siderska [7] and Kaarnijoki [8]. **Fig. 2** shows the graphical representation proposed by van der Aalst et al. [9].

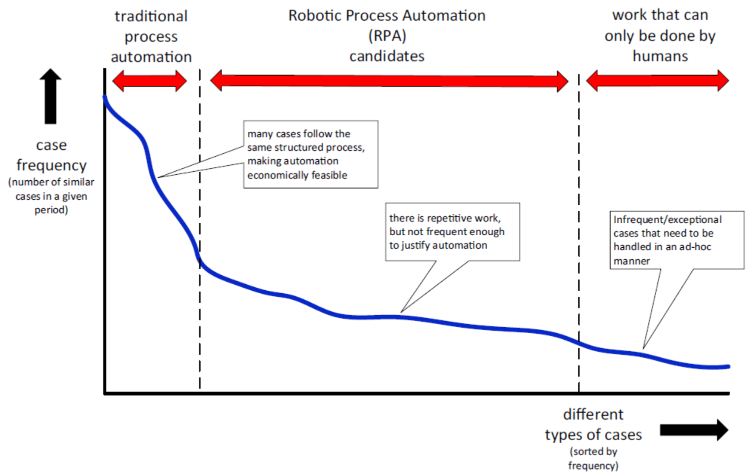

Fig. 2. Positioning RPA. (Source: van der Aalst et al. [9]).

Considering the content presented in **Table 2** and **Fig. 2**, it is evident that, from an economic perspective, the RPA candidate's processes are those where there is repetitive work but not frequent enough to justify the traditional process automation. On the other hand, when we have infrequent and exceptionalities cases, it must be done by humans. In addition, König et al. [10] claim that *"RPA is limited in that many techniques required to successfully implement it lay outside its scope. This includes gathering the necessary information for automation enactment, dealing with exceptions during the execution of automated processes, and managing process automation on an organizational level"* [10, p. 132].

To deal with RPA constraints, various authors propose an integrated approach between RPA and other research topics. Liermann et al. [22] propose a algorithm-driven decision-making solution in the automated process. Moreover, Martins et al. [23], propose to use Machine Learning (ML) to create cognitive RPA.

Yatskiv et al. [12] and Kaarnijoki [8] propose an integrated approach between RPA and Artificial Intelligence (AI) in order to use AI capabilities to complement RPA. Furthermore, Nakano [13] claims that *"in this process of interconnectedness, Artificial Intelligence (AI) and Robot Process Automation (RPA) are disruptive and promise emerging technologies"* [13, p. 51]. The author presents a study on AI and RPA's effects on the accounting and auditing fields in Japanese society. Patel et al. [24] integrated Machine Learning (ML) and RPA techniques to customize an automated email response bot. Hartmann [14] presents the chances and risks of RPA and AI for process optimization within the supply chain. Bellman and Göransson [25] present a framework to bridge RPA and AI. Finally, Parchande et al. [26] integrated RPA with a ML technique to develop a contractual employee management system. These approaches were developed to solve a specific problem and in a specific context.

3.4 Artificial Intelligence

The term Artificial Intelligence (AI) was formally proposed at a conference at Dartmouth University in 1956[According to Hu and Jiang [27] *"The Dartmouth Conference of 1956 proposed that 'every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it.' The Conference was the moment that artificial intelligence gained its name, its mission, its first success and its major players, and is widely recognised as the birth of artificial intelligence"* [27, p. 241]. According to Nunes et al. [28], AI can be defined as the *"ability of a system to correctly interpret external data, learn from that data, and use that learning to achieve specific goals and tasks through flexible adaptation"* [28, p 2].

AI is one of the most promising areas of computer science, and AI techniques are expected to solve complex problems faster and more accurately than humans, including problems for which currently there are no solutions. It is about the ability of machines and software to make decisions based on the analysis of a set of received information. Moreover, AI solutions must be able to learn by accumulating knowledge and successfully applying it.

For the last seven decades, AI has experienced a long development process that has brought us to the current scenario where AI algorithms and ML techniques have been successfully used in several business areas, such as commerce, industry, and digital services. In this scenario, ML has been a critical component of organizations' digital transformation. The basic idea behind ML is to teach machines how to learn from data more efficiently through AI techniques embedded in reasoning techniques such as statistics, probabilities, use cases, etc. [4], [29]. These AI algorithms enable organizations to develop solutions to extract, classify information, associate, optimize, group, predict, identify patterns, etc.

According to Grekousis [30], there are four main categories of learning methods:

- supervised (labelled data);
- unsupervised (unlabeled data);

- semi-supervised (labelled data only for a small portion of the training dataset); and
- reinforcement (via a system of sensors interacting with a dynamic environment to obtain and analyze data on the fly).

In order to select the appropriate learning category, we need to consider the given problem. Grekousis [30] also claims two categories of learning: shallow and deep learning. The main difference between the two categories lies in the depth of the analysis.

Finally, it is essential to highlight the increase in the number of applications that use AI, ML and RPA technologies, including a combination of these and other related technologies. According to Ribeiro et al. [4], "*given the scope of the applicability of AI, RPA has gradually been adding, to its automation features, implementations of algorithms or AI techniques applied in certain contexts (e.g., Enterprise Resource Planning, Accounting, Human Resources) to classify, recognise, categorise, etc. In recent years, some academic studies have been published as challenges and potential, as well as case studies of the applicability of RPA and AI*" [4, p. 53].

3.5 Hyperautomation

According to Bornet et al. [18], *"Intelligent Automation (IA) or 'Intelligent Process Automation', is a new notion, officially coined in 2017 by Institute of Electrical and Electronics Engineers. More recently, IA has been given different names, including Hyperautomation (by Gartner), Integrated Automation Platform (by Horses For Sources), and Cognitive Automation (by several sources)"* [18, p. 25].

It is about to apply the power of AI capabilities in robotics in order to meet most of the needs both can't satisfy individually. Hyperautomation combines AI capabilities with robotics capabilities and complements each other by connecting these capabilities. **Fig. 3** shows the positioning of Hyperautomation with other recent technology concepts proposed by Bornet et al. [18].

Madakan et al. [31] claim that *"Hyperautomation involves cutting-edge technologies such as artificial intelligence, machine learning and others to automate business operations, processes, services and thus complement human talent"* [31, p. 2]. It is an advanced version of automation followed by RPA. But the point of Hyperautomation is not to replace humans because when you handle repetitive tasks in an automated way you free up your workforce and allow them to focus on more strategic and cognitive tasks.

Martins et al. [23] propose an RPA application, which in real-time, dynamically detects objects in software applications interface. To do that, the authors trained a Convolution Neural Network (CNN) by using several interfaces and menus and used them to classify software interfaces in real-time. Furthermore, a developed software takes automated actions like moving the mouse pointer, editing text, clicking, etc.

The authors claim the techniques *"based on deep learning is capable of detecting objects in real-time, classify them, with outstanding accuracy, and take dynamic actions"* [23, p. 1].

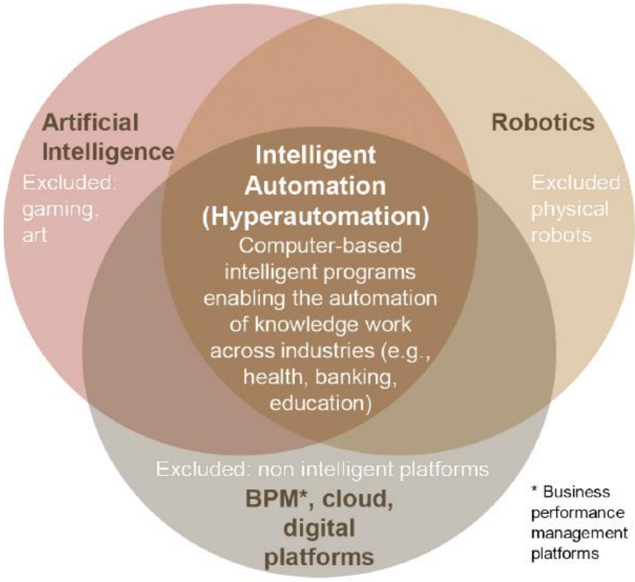

Fig. 3. Positioning RPA. (Source: van der Bornet et al. [18]).

Finally, Jha et al. [32] point that *"Process Automation has the potential to bring great benefits for businesses and organizations especially in the financial services industry where businesses are information-intensive and experience rich data flows. This was achieved mainly via Robotic Process Automation (RPA), but the increased complexity of the Machine Learning (ML) algorithms increased the possibility of integrating classic RPA with Artificial Intelligence (AI)"* [32, p. 1].

4 Proposed Solution

The proposed solution is to develop an integrated approach using RPA and AI that improves RPA adaptability to handle changes and makes it less error-prone to leverage RPA as a digital disruption technology widely used in organizations' DX processes.

In order to do that we need do analyze some AI techniques to define how these techniques, such as those proposed by Martins et al. [23], Jha et al. [32], O. I. Abiodun et al. [33], Somvanshi et al. [34], Charbuty and Abdulazeez [35] or Kuo and Huang [36], can be applied in RPA solutions in order to mitigate some of their constraints, especially to improve RPA adaptability to handle changes and make it less error-prone. This is **Artifact 1**. Secondly, we need to define a framework for applying Artifact 1 in the organization's DX processes. This is **Artifact 2**. **Artifacts 1 and 2** make up the RPA/AI (Hyperautomation) solution. **Fig. 4** illustrates this scenario.

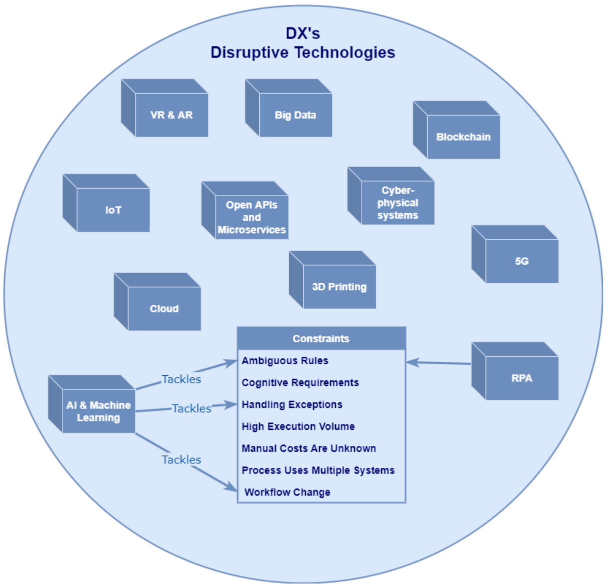

Fig. 4. Integration between AI techniques and RPA in the context of DX.

In the next step, we will demonstrate the use of the artefact to solve one or more instances of the problem by performing simulations and case studies. For this, we will analyze the impact of RPA solutions (RPA solutions without embedded AI techniques) in organizations' DX processes and the impact of **Artifacts 1 and 2** (RPA/AI solutions) in organizations' DX processes.

Next, we will compare the objectives of the solution to actual observed results from using the RPA/IA solution in the demonstration. The objective is to demonstrate how well the developed artefact supports the solution to the problem. For this, we will define success indicators and metrics, run the solution, measure them, and analyze the results.

The next step is to compare the results of the impact of RPA solutions (RPA solutions without embedded AI techniques) in organizations' DX processes with the analysis of the impact of the RPA/AI solution in organizations' DX processes. **Artifacts 1 and 2** (RPA/AI solution) are expected to perform better than RPA (RPA solution without embedded AI techniques).

5 Conclusions

Considering the current scenario, in which society is experiencing the emergence of new ways of consuming, buying, communicating, and offering products and services, organizations undergo a multidimensional transformation. DX is one of the critical pieces of this puzzle. However, before adopting disruptive digital technologies such as RPA, AI or ML, organizations need to consider the benefits and risks these technologies can bring.

This paper highlights the possibility to RPA be used in organizations' digital transformation process as a disruptive digital technology. For that, RPA must be more reliable and must be capable of operating in dynamic environments where changes are part of the daily work and the cost for implementing them may not be that high.

So, defining an integrated approach using RPA and AI will allow RPA to take a step forward, making this technology more reliable to use in large companies, startups, and small and medium-sized companies. This has the potential to make RPA a highly disruptive technology for organizations that are experiencing a DX process.

As a limitation of this work, we point out that this research considered a literature review and the implementation should be carried out in the next step. Once this approach is operational, as future works, we suggest conducting surveys in startups and small and medium-sized companies to determine the Return On Investment (ROI) that using hyperatumation is bringing them.

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