A Method to Select Processes for Automation

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Abstract

Organizations are more frequently turning towards process automation as a solution for employees to focus on higher complexity and more valuable tasks while delegating routine, monotonous and rule-based tasks to their digital colleagues. However, current process identification methods are not qualified for accurately selecting suitable processes for automation. Wrong process selection and resulting failed attempts are often the origin of process automation bad reputation within organizations and resulting avoidance of this technology. Consequently, in this research, a method for selecting processes for automation based on multi-criteria decision making techniques, such as AHP-TOPSIS will be demonstrated and evaluated. This study follows the design science research methodology and applies the proposed method to a real-life scenario.

Keywords

RPA · Robotic Process Automation · Software Robots · Process Suitability · Process Selection

Resumo

Com cada vez maior frequência, as organizações recorrem à automatização de processos como solução para garantir aos seus funcionários a capacidade de se focarem em tarefas mais complexas e valiosas, delegando tarefas monótonas, rotineiras, baseadas em regras aos seus colegas digitais. Porém, os atuais métodos de identificação de processos não são capazes escolher os processos com maior potencial para serem automatizados. A escolha errada de processos e consequentes falhas de adoção estão muitas vezes na origem da má reputação da automatização de processos dentro das empresas, levando-as a evitar esta tecnologia. Por conseguinte, nesta pesquisa, o método para seleção de processos para automatizar baseado no AHP-TOPSIS, método de decisão multicritério, será demonstrado e avaliado. Esta pesquisa segue a metodologia DSR (Design Science Research) e aplica o método proposto num contexto real.

Palavras Chave

RPA · Robotic Process Automation · Software Robots · Process Suitability · Process Selection

Table of Contents

List of Figures

List of Tables

Acronyms

AHP	Analytic Hierarchy Process
CoE	Center Of Excelence
CR	Consistency Ratio
DSRM	Design Science Research Methodology
MCDM	Multi Criteria Decision-Making
MADM	Multi Attribute Decision-Making
PoC	Proof Of Concept
RCI	Random Consistency Index
RPA	Robotic Process Automation
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution

1

Introduction

Contents

Organization leaders are becoming increasingly curious about robots' potential to improve businesses and increase returns [3]. The term ”robot” is most commonly imagined as physical machines moving around the office and performing human tasks. However, in the context of this article, this term is associated with service automation and refers to something less threatening. Robots are, in this scope, software that performs particular rule-based, repetitive, monotonous tasks previously performed by humans. As a result, humans can focus on more complex creative tasks [4]. Because it is software, it is used as a layer of logic on top of the underlying IT infrastructure without interfering. This non-invasive approach is achieved because these robots mimic the way humans perform tasks. They can log in using the user credentials, interpret text, tables, and figures, interact with the mouse through motion and clicking, write emails, fill out application forms and interact with data in multiple systems [3, 5].

The term robotic process automation (RPA) means applying these robots to business tasks that humans previously executed. Since its first implementation, Robotic Process Automation (RPA) has evolved from the automation of simple tasks performed by one user to a platform-based application with the ability to undertake large volumes of work and automate more complex business rules by orchestrating dozens of software ”robots” [6].

Robotic process automation (RPA) is a recent technology that promises to generate significant returns on investment for companies and organizations [5]. Enabling companies to free up resources and reallocate them to activities focused on creating business value and customer satisfaction, RPA can foster the emergence of new work forms and drive organizational competitiveness in the digital age [7]. The adoption of RPA in organizations, due to its cost reduction, efficiency improvement, productivity increase, and service quality enhancement, has rapidly increased in recent years. However, specific core questions must be revisited and answered, as with any emerging technology, as most conducted researches are either case studies or market research [8–10].

1.1 Research Problem

One central question of RPA projects pertains to selecting the most suitable processes for automation [11]. Robotic process automation is not a one-size-fits-all solution. It requires careful analyses and informed decision-making, and, as a result, the success of these projects is highly dependent on a process's automation potential and its characteristics. Hence, companies must understand where their processes stand in the scope of RPA to ensure that its' adoption is successful and provides the desired return on investment [7]. Accordingly, this thesis aims to provide organizations with a method to evaluate RPA automation candidates and rank them according to their automation potential. This process evaluation depends on the characteristics that make processes suitable for automation found in the current literature.

This research proposes a method to help organizations achieve better results when selecting the processes for automation through Multi-Criteria Decision Making (MCDM). When presented with multiple criteria, these methods provide support for decision-making. Each Multi Criteria Decision-Making (MCDM) method has its' theoretical foundations, strengths, and weaknesses [12, 13]. In this study the chosen method is AHP-TOPSIS. This Multi-Attribute Decision Making (MADM) method uses the analytic hierarchy process (AHP) for determining the decision criteria weights, followed up by the technique for order preference by similarity to the ideal solution (TOPSIS) to evaluate and rank the processes in regards to their closeness to the optimal solution.

The AHP, developed by Saaty, is an approach that simplifies complex and ill-structured problems through a series of pairwise comparisons by organizing the decision criteria in a hierarchical structure and attributing them a weight regarding their contribution to the desired goal [2, 14]. This method is commonly applied in complex scenarios, where collaboration is required to make decisions, and human perceptions, judgments, and consequences have long-term repercussions.

The rank reversal issue, a prevalent topic in decision-making, is the change in the ranking of alternatives when a non-optimal alternative is introduced. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method has been demonstrated to be one of the best methods to deal with this issue [15]. In addition, the rank reversal in TOPSIS is insensitive to the number of solutions and performs worst only in the case of a few criteria [15, 16]. An advantage of TOPSIS against other Multi Attribute Decision-Making (MADM) methods is its ability to identify the best alternative faster than other methods [17].

1.2 Organization of the Document

This thesis is organized as follows. In Chapter 2, a theoretical background with information related to the topics of robotic process automation, process suitability and the AHP-TOPSIS method is provided. In Chapter 3, the research methodology is described. In Chapter 4, the proposed method is explained. In Chapter 5 a demonstration of the method application is made. In Chapter 6, an evaluation of the methods results is presented. In Chapter **??**, a description of how the research was communicated is provided. Finally, a concluding remark is presented in Chapter 7, which includes the present work contribution, limitation and possible future work.

2

Research Background

Contents

In this chapter, a theoretical background on the topics related to this research is presented.

2.1 Robotic Process Automation (RPA)

In this chapter a context to robotic process automation and the adoption of this technology is provided.

One of the core areas of business IT is the optimization and automation of business processes [11]. This area ranges from individual activities to automation of complete end-to-end processes [18] and is one of the current main digitization challenges for organizations [19–21].

In the past decades, several traditional methods of business process automation, such as core application systems, BPM systems, and middleware systems [22, 23], have been implemented. Unlike these solutions, RPA is a lightweight approach that allows non-intrusive automation of existing application systems [4, 24, 25]. These robots can be created through scripts, screen scraping, and macros and use ready-made standard modules.

2.1.1 RPA Implementation Features

In the current literature it was possible to identify that although implementations of RPA's differ from each other based on several factors such as company size, maturity, and area of work, there were still some common denominators (Table 2.1).

Table 2.1: RPA Implementation Features

Feature	Sources
Proof Of Concept	[5, 25–35]
Center Of Excellence	[27, 29–31, 34, 36–39]
Training	[5, 27, 29, 32, 39–43]
RPA Ambassadors	[5, 34, 37, 41, 42, 44, 45]
Removal of Fear of Job Losses	[5, 25, 35, 36, 42, 46, 47]
RPA Seminars	[5, 27, 34, 42, 46, 48]
Communication Expert-Developer	[5, 29, 30, 36, 39]
Data and Task Standardization	[29, 31, 40, 49]
Back-Up Strategies	[5, 31, 49]

Most companies followed a 4-stage implementation framework consisting of identifying tasks, redefining processes from AS-IS to TO-BE, developing the bot, and finally monitoring its actions [30]. Other companies adopted a similar 5-stage framework that would include a testing phase after developing the bot and before its deployment [44].

Regarding regular features of adoption, most implementations started with a proof of concept (Proof Of Concept (PoC)), which intended to demonstrate RPA capabilities and potentials for the company.

Low-complexity, high volume/value processes were regularly chosen as PoC, to achieve what some literature calls ”quick wins” [25,27,44].

Centers of Excellence (CoE) are also commonly implemented when adopting RPA in a company. When compared against outsourcing, Center Of Excelence (CoE)’s provide critical benefits such as familiarity with the processes, access to confidential information, and the environments where the robots will be implemented facilitating bot testing and deployment. [45].

Research articles also highlighted the importance of integrating RPA into the company’s culture. To achieve this cultural shift, it was common for organizations to host regular RPA Seminars, where RPA potentials and benefits were showcased through test cases, and implement RPA Ambassadors, who would foster a positive outlook on the technology inside the company. Removal of workers’ fear of job loss was also critical in this process, and it was usually achieved by showing RPA benefits and reframing their implementation as a way to free employees from tedious tasks and allow them to work on higher complexity ones instead of a means to replace them [36,38].

Other recurrent characteristics of successful implementations include training employees to understand and work with RPAs, focusing on good communication between process experts and RPA developers, standardizing data and tasks, and having backup strategies in place if an RPA deployment fails.

2.1.2 RPA Benefits

Several benefits seem to arise from the successful adoption of these digital workers within an organization. In this chapter, the benefits found in the literature (Tab. 2.2) will be analyzed.

Table 2.2: RPA Benefits

Benefit	Sources
More insightful work	[29,31,36,38,40,41,43,44,48–52]
Reduced Process Hours	[26,28,31,35,39,42,43,48,50,53,54]
Lower Error Rate	[27,28,31,35,39,45,50–52,55]
Cost Saving	[26,31,38,39,42–44,52]
Customer Service and Satisfaction	[41,43,48,50,51,53]
Working 24/7	[27,38,41,42,52]
Improvement in staff skills	[36,48,51,52]
Standardization	[38,39]

The most mentioned benefit across the articles was that, given RPA performing more tedious and monotonous work, workers were able to focus and invest their time in more complex, meaningful tasks that provide more value to the company [52]. Another observed benefit was that as a result of performing new or more meaningful tasks, employees would also invest more time in developing new skills to become more qualified at their specific job [36].

Conferring RPA the responsibility of handling repetitive and tiring tasks also contributed to a lower error rate due to the elimination of human errors. Unlike humans, the bots do not get tired and therefore aren't susceptible to making the same mistakes that humans would [55]. On the other hand, automated processes are vulnerable to systematic errors due to bad RPA programming [28].

Articles also documented improved customer service and consequent satisfaction. This benefit resulted from several factors such as faster and smoother process execution which led to rapid responses to customers' requests and employees feeling less pressured to rush through interactions with clients [48].

An observable quantitative benefit of successful implementations was process efficiency, achieved through cost savings, with articles reporting between 25% and 75% [39, 42], and through process time reduction, with companies stating that some processes would take a 10th of the time of what they used to [39]. Not only did business processes become more efficient, but the articles also highlighted the ability of bots to work at any time of every day. As a result, not only do processes take less time but the amount of time available to complete them also increased [41]. Most companies implementing RPA also felt the collateral benefits of standardizing and improving their processes. It is necessary for documents to be structured and standardized and for processes to be stable and mature to integrate this technology. As a result, it is fair to classify standardization as an advantage that emerges from the intent to adopt RPA [39].

Other impacts of these digital workers were: reduction in office space costs by 40% [39], more efficient coping with employees absence, as there was less redistribution of work because RPA could take over basic repetitive tasks, allowing for less office time and more remote work [32] and allowing for business continuity during unexpected events, such as COVID-19 [56].

2.1.3 RPA Challenges

Just like benefits, there were several challenges reported throughout the literature (Tab. 2.3), with some being more predominant than others and most originating from the newness of the technology.

Table 2.3: RPA Challenges

Challenge	Sources
Lack of knowledge and experience	[25, 27–29, 31, 38, 42, 49, 57]
Employee and Stakeholder Resistance	[27, 28, 38, 40, 41, 43, 57]
Access and Security Issues	[28, 31, 33, 34, 38, 49]
Data Incompatibility	[28, 29, 42, 58]
Lack of Documentation	[31, 34, 45]
Unfit Processes	[29, 41, 47]

RPA is such a recent technology that there is a lack of knowledge and experience in its implementation [28, 59]. Not only do companies have issues with finding the right solutions for their situation, but there is also an internal resistance to adapting to a new culture. An example is the employee's lack of awareness of the impact that this adoption may bring to their work (system, document structure, and other changes) [38].

The cultural resistance to change emerges on account of the lack of knowledge and experience with this software. Firstly, unless forced to, some employees avoided implementing this new technology out of fear of job loss, which led to less adherence [40]. Secondly, some stakeholders failed to endorse and prioritize this adoption due to being comfortable with current work cultures [41]. Together, this lack of urge and desire to innovate poses a critical challenge to RPA implementation.

Although most companies have started to use digital documentation as a more flexible and modern way to store information, others are still lagging. The use of paper, unstructured documents is still a substantial impediment to RPA adoption in organizations [59]. To automate any business process, companies must have structured documents stored digitally.

Understanding which processes are fit for automation is crucial for the success of the adoption of these digital workers. By contrast, attempting to automate unfit processes seemed to be a recurring challenge across organizations. Trying to automate manual, complex, or highly fractional (with multiple parties involved) is a challenge that companies face due to a lack of knowledge and preparation. In these cases, either redesigning the process or choosing a fitter process for automation appeared to be the best solution.

Access and security also pose key issues to RPA implementations. Managing access to resources has always been done with humans. However, with software robots, new measures must take into account robots' access to information [33, 34]. In the same way, current security practices do not take into account the existence of digital workers, and successfully implementing a new security framework constitutes a significant challenge to organizations [49]. The novelty of the software and the resulting lack of documentation makes it challenging for companies to adopt RPA as there are currently no standards and methodologies in place [60].

2.2 Process Criteria for Automation

Being the first step of any RPA adoption, process selection is core for its' success, as choosing an unsuitable process will lead to poor outcomes and a negative outlook on the technology. Because of its low implementation cost and high potential benefits, the interest of companies in adopting this technology has been increasing in recent years [30, 35, 38]. However, selecting other processes to automate becomes more challenging, as their complexity, volume, or value are not so evidently more significant than the remaining [61]. In principle, various processes are suitable for automation [61], with the literature emphasizing specific process characteristics. The following characteristics are most commonly found in literature:

1. Rule-based - clear and concise rules govern most decisions along the process. Therefore these can be automated through if-then decision trees [5,29,31,37,38,41,49];
2. Mature - minimal changes in the past and the expectation of future changes also being minimal to none. As a result, outcomes and costs are easier to predict and benefits can be estimated by comparison with the process history [29,41,42,45,56];
3. Structured and digital data - data need to be structured to consistently provide the same information for the robot in the same place. Structuring allows the software bot to find the required data expected for processing. Otherwise, it would be hard for the bot to fetch the data, and it would be prone to errors due to mistaking different information fields. Data should also be digital for the robot to access and then process. Physical documents can be scanned using optical character recognition (OCR), however RPA tends to be more successful with the digital format of data that eliminates the possibility of document misreading [31,35,38,42,45,56];
4. Volume - processes performed frequently by several people or take longer to be done. For any organization, tasks of this sort should be a priority for automation as they yield the highest potential benefits and return on investment (ROI) [29,31,38,41,42,49,56,62];
5. Complexity - processes should be sufficiently simple that allows for faster robot development and deployment. Increased process complexity causes increased robot complexity and, with it, operation costs [63,64];
6. Multiple systems - under the same conditions, processes that interact with more systems are more suitable for automation. As a result, the technology acts as a top layer providing integration between the different systems [31,41];
7. Human input - repetitive, monotonous tasks that require human input are more prone to errors from fatigue [49,59].

2.3 AHP-TOPSIS

This chapter provides a context to the used Multi-Criteria Decision Making algorithm, AHP-TOPSIS.

Numerous researchers have dedicated their effort to developing the best decision-making methodologies over the last decades. AHP-TOPSIS is designed with the most efficient use of Multiple-Criteria Decision Making techniques possible [14,65]. Analytic Hierarchy Process (AHP) and TOPSIS, two of those techniques, are combined to rank alternatives according to specific criteria. In this research, the AHP technique is used to structure the decision hierarchy of the problem, while TOPSIS is employed to rank the existing alternatives. An illustration of the application of this techniques is presented on Fig. 2.1.

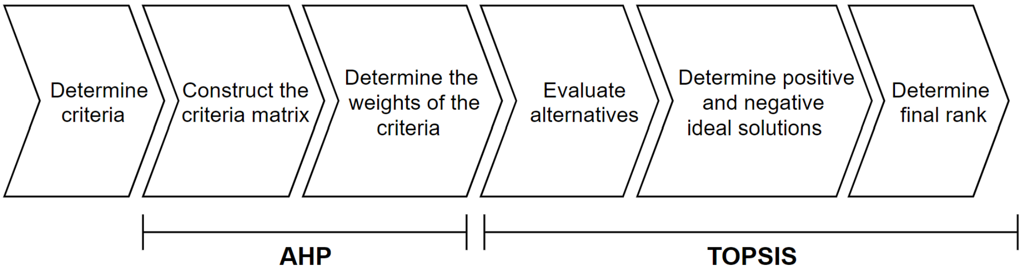

Figure 2.1: Generic AHP-TOPSIS methodology

2.3.1 Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) [2] is a flexible and effective MCDM method. This method helps establish priorities and make the best decision when both quantitative and qualitative aspects of a decision need to be assessed [66, 67].

AHP is one of the most vastly used decision-making techniques in cases when the decision is based on several criteria. It has been applied in various fields, such as management, governance and agriculture, to name a few, with the purpose of making strategic decisions of significant importance and responsibility [68].

Although this method consists, on the problem decomposition into a hierarchy structure which consists of the goal, the criteria the alternatives [69], in this research it will only be used to obtain the criteria weights. This process consists of the following steps [70, 71]:

1. Structure the decision hierarchy with a top-down approach (Fig. 2.2). The hierarch starts with the goal of the decision at the top, then the intermediate levels with the criteria and sub-criteria, to the lowest level (which usually is a set of the alternatives);

2. According to the ”Fundamental Scale of AHP” (Table 2.4), fill the comparison matrix in which every element from the set of criteria is compared to itself through a pair-wise comparison;

3. Given the comparison matrix $M \in \mathbb{R}^{n\times n}$, using the average of normalized column (ANC) method,

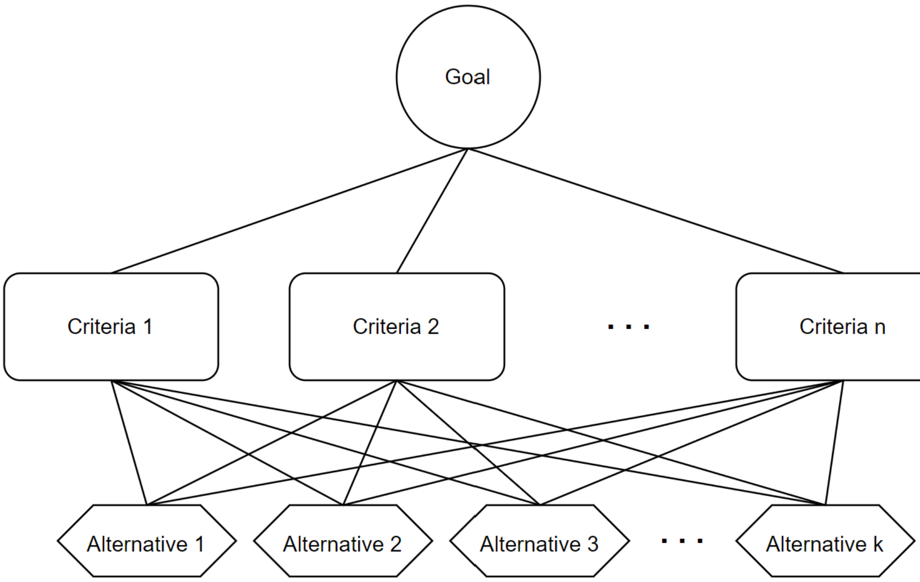

Figure 2.2: Generic Three-Layer AHP Hierarchy

obtain the vector of priorities $V \in \mathbb{R}^n$. In mathematical form, the vector can be calculated as:

$$V = \begin{bmatrix} V_1 \\ V_2 \\ \dots \\ V_n \end{bmatrix} \quad , \quad V_i = \frac{\sum\limits_{j=1}^{n} \overline{M_{ij}}}{n}. \tag{2.1}$$

where,

$$\overline{M_{ij}} = \frac{M_{ij}}{\sum\limits_{i=1}^{n} M_{ij}} \quad , \quad \forall j \in \{1, n\} \tag{2.2}$$

4. Verify that the consistency of judgments is valid by, calculating the Principal Eigen Value (λ) of the pair-wise comparisons matrix.

$$\lambda = V_1 \times \sum_{i=1}^{n} M_{i1} + V_2 \times \sum_{i=1}^{n} M_{i2} + ... + V_n \times \sum_{i=1}^{n} M_{in} \tag{2.3}$$

and then obtaining the Consistency Index (CI),

$$CI = \frac{\lambda - n}{n - 1} \tag{2.4}$$

Table 2.4: Fundamental scale of AHP from [2].

Intensity	Definition	Explanation
1	Equal Importance	Two criteria contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one criteria over another
5	Strong importance	Experience and judgment strongly favor one criteria over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation

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[a] Intensities of 2, 4, 6 and 8 can be used to express intermediate values.

[b] If a criteria c1 has an intensity I compared to c2. By comparing c2 to c1, I is obtained.

The Consistency Ratio (CR) is then defined by:

$$CR = \frac{CI}{RCI} \tag{2.5}$$

where Random Consistency Index (RCI) is a random consistency index, depending on the number of criteria (Table 2.5). For the judgments to be coherent, a value of Consistency Ratio (CR) less than 0.1 is generally acceptable, otherwise the pair-wise comparisons should be revised to reduce incoherence [2].

Table 2.5: Random Consistency Index Table from [2]

n	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	.52	.89	1.11	1.25	1.35	1.40	1.45	1.49

2.3.2 Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

Hwang and Yoon created the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) technique [72] based on the fundamental idea that the chosen alternatives should be the closest to the positive ideal solution (S+) and the farthest distance from the negative ideal solution (S-) [65]. This approach presumes that each criterion leans towards a monotonically decreasing or increasing utility

[73], and the preference order of the presented alternatives could be determined by comparing these relative distances [16].

Several exciting studies have focused on the TOPSIS technique and applied it in several fields, from supplier selection to tourism destination evaluation, financial performance evaluation, location selection, and others. In the literature, we can find examples of these studies, such as ETL software selection [74], customer-driven product design process [75], and open-source EMR software packages [76].

The steps of the TOPSIS approach are as follows [77, 78]:

1. Establish a decision matrix for the ranking, where each row represents an alternative and each column a criterion;

2. Normalize the decision matrix using the following equation:

$$\overline{A_{ij}} = \frac{A_{ij}}{\sqrt{\sum\limits_{i=1}^{m}(A_{ij})^2}} \tag{2.6}$$

3. Using the weights previously attributed to the criteria, calculate the weighted normalized decision matrix $\overline{A^*} \in \mathbb{R}^{m\times n}$. Given the priority vector $V \in \mathbb{R}^n$, then

$$\overline{A^*_{ij}} = V_i \times \overline{A_{ij}}\ , \quad \forall j \in \{1, n\} \tag{2.7}$$

4. Calculate the positive and negative ideal solutions as follows,

$$S^+ = \begin{bmatrix} \max(\overline{A^*_{11}}, \overline{A^*_{21}}, ..., \overline{A^*_{m1}}) \\ \max(\overline{A^*_{12}}, \overline{A^*_{22}}, ..., \overline{A^*_{m2}}) \\ ... \\ \max(\overline{A^*_{1n}}, \overline{A^*_{2n}}, ..., \overline{A^*_{mn}}) \end{bmatrix} \ , \ S^- = \begin{bmatrix} \min(\overline{A^*_{11}}, \overline{A^*_{21}}, ..., \overline{A^*_{m1}}) \\ \min(\overline{A^*_{12}}, \overline{A^*_{22}}, ..., \overline{A^*_{m2}}) \\ ... \\ \min(\overline{A^*_{1n}}, \overline{A^*_{2n}}, ..., \overline{A^*_{mn}}) \end{bmatrix} \tag{2.8}$$

5. Compute the Euclidean distance to evaluate how close each alternative is to the ideal positive and negative solutions,

$$D^+ = \begin{bmatrix} \sum\limits_{i=1}^{n}(\overline{A^*_{1i}} - S_i^+)^2 \\ \sum\limits_{i=1}^{n}(\overline{A^*_{2i}} - S_i^+)^2 \\ ... \\ \sum\limits_{i=1}^{n}(\overline{A^*_{mi}} - S_i^+)^2 \end{bmatrix} \ , \ D^- = \begin{bmatrix} \sum\limits_{i=1}^{n}(\overline{A^*_{1i}} - S_i^-)^2 \\ \sum\limits_{i=1}^{n}(\overline{A^*_{2i}} - S_i^-)^2 \\ ... \\ \sum\limits_{i=1}^{n}(\overline{A^*_{mi}} - S_i^-)^2 \end{bmatrix} \tag{2.9}$$

6. The closeness to the optimal solution (C_i), for every alternative i can be calculated as:

$$C_i = \frac{D_i^-}{D_i^- + D_i^+} \tag{2.10}$$

where the larger C_i the better the performance of the alternative, with the optimal alternative being the one with the value closest to 1.

This technique usually deals with benefit and cost data. In this thesis, all criteria are of benefit type. Therefore, the higher the value attributed to the criteria, the better.

3

Research Methodology

Design science research is one of the two paradigms that characterize research in Information Systems. This paradigm aims to create and evaluate new technological artifacts that help organizations handle core information-related tasks [79]. The Design Science Research Methodology (DSRM) requires a strict procedure to design artifacts that aim to solve problems, make research contributions, evaluate the designs, and communicate the results to the appropriate audiences [79]. IT artifacts can be: 1) constructs that compose the language by which the problems and solutions are defined and communicated [79], 2) models that use constructs to represent a real-world situation - the design problem and its solution [80], 3) methods that provide a solution to the problems [79] or 4) instantiations that show that the implementation of constructs, models, or methods in a working system is feasible [79].

As a result, a six-step procedure is followed for conducting the DSRM [1]:

1. Problem Identification and Motivation: In the first step occurs the identification and specification of the research problem, followed by an explanation of the value of developing a solution;
2. Definition of the Goals for a Solution: In the second step occurs the expression of the purposes of finding a solution for the problem identified in the previous step;
3. Design and Development: In the third step, the decision on the technological artifact's desired functionality and determination of its architecture takes place. The artifact, which can be any designed object with an included research contribution in its design, is then created;
4. Demonstration: In the fourth step, the aim is to demonstrate how the artifact developed in the previous step helps solve one or more cases of the problem;
5. Evaluation: In this step, occurs observation and measurement of the artifacts' effectiveness in solving the problem. This solution is then compared with the results from the demonstration;
6. Communication: In the last step, occurs an exposition of the problem and its relevance, the artifact and its utility, uniqueness, and effectiveness to researchers and other relevant audiences.

The application of the DSRM to this research is presented in Fig. 3.1 and will be further explained throughout the following chapters of this thesis.

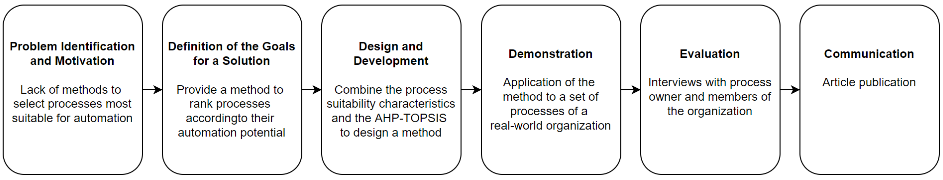

Figure 3.1: Six steps from DSRM adapted from [1]

4

Proposal

Contents

This chapter corresponds to the second phase of the DSRM methodology and is where a solution to the problem of process selection for RPA adoption will be proposed.

4.1 Objective

The primary objective of this thesis is to provide a method that allows organizations to obtain a list of processes prioritized by their suitability for robotic process automation. This method considers both processes characteristics and the organizations' goals.

Given the purpose of this proposal, it is possible to infer that the proposed method tries to capture all real benefits associated with proper RPA adoption and attempts to either solve or mitigate the previously identified errors: poor outcomes of RPA implementation resulting from the lack of frameworks and consequently choosing unsuitable processes (Chapter 1).

To guarantee that the method is of any value, the criteria used for process selection are coherent with the literature's characteristics and previously presented (Chapter 1). As a result, the method will not only be evaluated on its ability to solve the identified problem but also on its ability to provide value to organizations in real-world scenarios.

4.2 Description

The AHP-TOPSIS is adopted to solve the previously mentioned problem. An application of this method to the problem context requires the criteria and their relative importance, the alternatives and their evaluation:

1. Criteria: the criteria chosen for AHP-TOPSIS consist of 9 criteria based on the previously conducted literature review. These criteria, previously presented (Chapter 2.2), are rule-based, maturity, data structure, digital data, human input, complexity, multiple systems, frequency, and duration;

2. Relative importance: the pair-wise comparison matrix was filled according to the ”Fundamental Scale of AHP” (Table 2.4) and the information found across the examined literature;

3. Alternatives: in this context, the alternatives for the AHP-TOPSIS method are the processes to be automated potentially;

4. Evaluation: the evaluation of these processes (alternatives) according to their characteristics (criteria) should be done by those with a more practical understanding of them, for example, the process owner. This evaluation requires the design of a scale for each chosen criteria.

It should be noted that the provided set of criteria and their relative importance are only a basis, and that can be customized if desired. One of the advantages of this method is that it gives the organization complete control over the chosen criteria, alternatives, relative importance and evaluation scales, enabling any addition or removal of process characteristics. It also allows for hypotheses and theories testing regardless of the purposes being scientific or businesslike. As mentioned, any characteristics can be added or removed without affecting the normal working of the method. When a new characteristic is added, it is only necessary to provide its relative importance to the remaining ones such that the coherency ratio remains below 10%.

The provided method for selecting processes for robotic process automation (Fig. 4.1) can be divided in the following 6-steps:

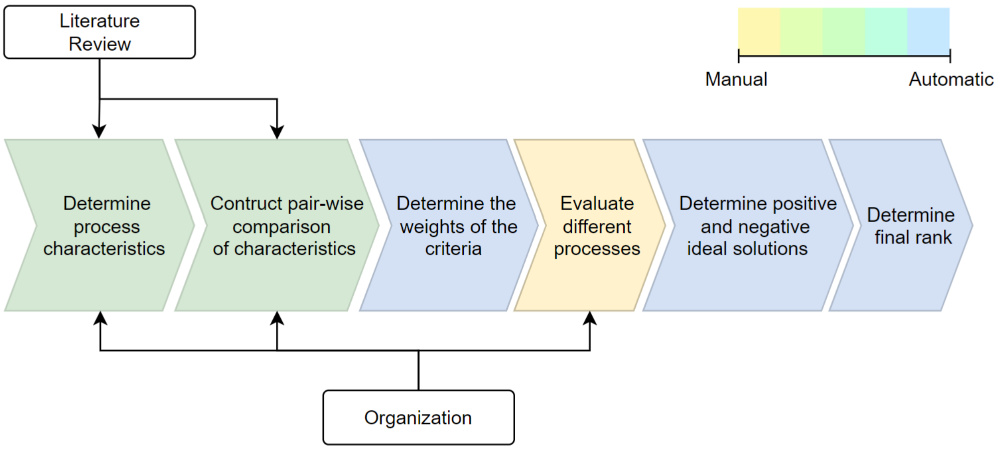

Figure 4.1: Method for selecting processes for automation.

4.2.1 Determine Process Characteristics

At first, the process characteristics used as criteria for the process selection are defined. This thesis provides a standard set of criteria based on the found literature. Organizations can, however, modify these criteria to their own goals as intended.

4.2.2 Construct pair-wise comparison of characteristics

Once criteria are defined, pair-wise comparison of these criteria must be made, according to the "Fundamental Scale of AHP". As in the previous step, this thesis also provides a standard pair-wise comparison matrix based on the literature that may also be adapted.

4.2.3 Determine the weights of the criteria

In this step occurs the application of the AHP method calculations. The weights of each criterion are obtained according to the equations 2.1 and 2.2. To guarantee the validity of the proposed comparison matrix, equations 2.3, 2.4 and 2.5 are applied, and the obtained Consistency Ratio is evaluated against the threshold value of 10

4.2.4 Evaluate different processes

At this stage occurs the evaluation of processes according to the criteria defined in the first step. This evaluation requires the design and application of a properly defined scale. To ensure a proper evaluation, it is required for this step to be done by someone very acquainted with the processes, such as the process owner or a related business actor.

4.2.5 Determine positive and negative solutions

Once the process evaluation is done, the TOPSIS method calculations occur. The negative and positive ideal solutions are obtained by applying equations 2.6, 2.7 and 2.8 to the matrix containing the process evaluations and using the criteria weights obtained on step 3.

4.2.6 Determine the rank

In this final step, equations 2.9 and 2.10 are applied to obtain each process closeness to optimal. Processes are then ranked decreasingly according to the obtained value.

5

Demonstration

Contents

This chapter relates to the fourth phase of the DSRM, and discusses how the previously defined method was used to solve a real-world scenario of the research problem.

A brief overview of Técnico+ business background will be provided, to support the context for demonstrating this implementation. Técnico+ provides over 35 advanced education courses, adapted to all technical levels of professional necessities, for both organizations and individuals. It partners with more than 70 teachers and researchers, to provide courses on dozens of areas of specializations. Like all organizations, Técnico+ process efficiency needs to scale up to match their business growth while keeping costs low to thrive in the highly competitive education market. To achieve this outcome, Técnico+ needs to understand whether adopting robotic process automation will provide a return on their investment, if their processes are suitable for automation and, in that case, which processes should be prioritized at this stage.

5.1 Determine Process Characteristics

The standard process criteria for automation found in the literature and presented in Chapter 2.2 were used as the criteria to apply the method (Table 5.1).

Table 5.1: Criteria for Técnico+ Process Selection

Code	Process Characteristics	Explanation
RB	Rule-Based	Activities do not require human decision-making
M	Maturity	Process has not been recently adjusted or modified
DS	Data Structure	Data appears in documents in a structured format
DD	Digital Data	Data is stored in documents in digital format
HI	Human Input	Activities do not rely on human input prone to error, such as copying and inserting data
C	Complexity	Process is simple, with low variation and few execution paths
MS	Multiple Systems	Process interacts with several different systems
F	Frequency	Process happens frequently
D	Duration	Process execution takes a long time

5.2 Construct pair-wise comparison of characteristics

With criteria already defined, a pair-wise comparison of the process characteristics suitable for automation occurred. The comparison matrix was then filled (Table 5.2) according to the "Fundamental Scale of AHP", and the existing literature on robotic process automation.

Table 5.2: Pair-wise comparison matrix for Técnico+

	RB	M	DS	DD	HI	C	MS	F	D
RB	1	3	1	2	9	5	9	0.2	5
M	1/3	1	1/3	1/3	7	2	9	1/3	5
DS	1	3	1	1	9	7	9	1	6
DD	0.5	3	1	1	9	7	9	1	5
HI	1/9	1/7	1/9	1/9	1	0.25	0.25	1/7	0.2
C	0.2	0.5	1/7	1/7	4	1	1	1/7	1
MS	1/9	1/9	1/9	1/9	4	1	1	1/9	1
F	5	3	1	1	7	7	9	1	7
D	0.2	0.2	1/6	0.2	5	1	1	1/7	1

5.3 Determine the weights of the criteria

By applying the AHP method calculations mentioned on the equations 2.1 and 2.2 we obtain the normalized comparison matrix (Table 5.4) and the vector of priorities (Table 5.3).

Table 5.3: Vector of priorities

Criteria	Weight
RB	17.75%
M	9.51%
DS	19.11%
DD	24.32%
HI	1.53%
C	3.40%
MS	2.75%
F	24.32%
D	3.52%

To guarantee that the proposed comparison matrix is valid and coherent, equations 2.3, 2.4 and 2.5 are applied, obtaining a Consistency Ratio $(CR) \approx 9.88\%$, which is below the specified threshold.

Table 5.4: Normalized pair-wise comparison matrix for Técnico+

	RB	M	DS	DD	HI	C	MS	F	D
RB	0.118	0.215	0.206	0.339	0.164	0.160	0.187	0.049	0.160
M	0.039	0.072	0.069	0.057	0.127	0.064	0.187	0.082	0.160
DS	0.118	0.215	0.206	0.170	0.164	0.224	0.187	0.246	0.192
DD	0.591	0.215	0.206	0.170	0.127	0.224	0.187	0.246	0.224
HI	0.059	0.215	0.206	0.170	0.164	0.224	0.187	0.246	0.160
C	0.013	0.010	0.023	0.019	0.018	0.008	0.005	0.035	0.006
MS	0.024	0.036	0.029	0.024	0.073	0.032	0.021	0.035	0.032
F	0.013	0.008	0.023	0.019	0.073	0.032	0.021	0.027	0.032
D	0.024	0.014	0.034	0.034	0.091	0.032	0.021	0.035	0.032

5.4 Evaluate different processes

Once the weights of each process's suitability characteristics are calculated, evaluation of processes according to their characteristics occurs. For this evaluation, the scale on Table 5.6 was designed. A member of the organization with a vast knowledge of the processes was then responsible for evaluating them according to the scale (Table 5.5). The organization's CEO then revised this evaluation.

Table 5.5: Evaluation of Técnico+ processes according to the scale 5.6

Code	RB	M	DS	DD	HI	C	MS	F	D
7.01	1	5	3	3	3	5	4	4	3
7.02	2	5	5	2	5	3	2	3	3
7.03	3	5	5	3	5	4	3	4	3
7.04	5	4	5	3	5	5	5	1	1
7.05	4	5	5	3	3	4	2	4	5
7.06	3	4	4	3	5	4	5	3	2
7.07	4	5	5	4	5	4	5	3	2
7.08	4	5	5	4	5	5	5	3	3
7.09	2	5	4	4	5	4	5	3	1
7.10	3	4	4	3	5	4	2	3	4
7.11	2	4	3	3	4	4	2	3	3
7.12	1	5	5	3	4	4	4	2	2
7.13	4	5	1	3	2	5	5	1	1
7.14	5	5	5	3	5	5	5	2	1
7.15	3	4	2	3	5	3	4	3	3
7.16	2	4	5	3	5	4	4	2	2
7.17	3	4	5	3	5	4	2	3	3
7.18	3	5	5	2	5	4	2	5	4

Note: To apply this method, each process was attributed a specific code ranging from 7.01-18 to identify it.

Table 5.6: Scale for process evaluation for Técnico+

Criteria	Scale				
	1	2	3	4	5
RB	% of activities that do not require human decision-making				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
M	how many times was the process adjusted, modified or revised (in the last year)				
	5+	4	3	2	0-1
DS	% of stuctured data and documents				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
DD	% of digital data and documents				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
HI	% of activities that require human input				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
C	how complex are the process variations and execution paths				
	Very Complex	Somewhat Complex	Neutral	Somewhat Simple	Very Simple
MS	how many systems are involved in the process				
	1	2	3	4	5+
F	how often does the process happen				
	Less than once a month	Monthly	Every 2 weeks	Weekly	Daily
D	how much working time does the process require				
	Less than 15min	15min-1h	1h-3h	3h-6h	More than 6h

5.5 Determine positive and negative solutions

Once the process evaluation finished, the negative and positive ideal solutions were calculated by applying TOPSIS equations 2.6, 2.7 and 2.8 to the Table 5.5 with the process evaluations and using the criteria weights on Table 5.3.

5.6 Determine the rank

In the last step of the method, equations 2.9 and 2.10 were applied to obtain each process closeness to optimal. Processes were then ranked decreasingly according to the obtained value (Table 5.7).

Table 5.7: Process ranking according to suitability for automation

Rank	Code	Closeness to Optimal
1	7.08	0.98
2	7.07	0.97
3	7.14	0.93
4	7.04	0.92
5	7.05	0.87
6	7.03	0.83
7	7.17	0.82
8	7.10	0.79
9	7.06	0.78
10	7.09	0.70
11	7.18	0.67
12	7.16	0.66
13	7.15	0.59
14	7.02	0.52
15	7.11	0.47
16	7.12	0.44
17	7.13	0.43
18	7.01	0.25

6

Evaluation

This chapter corresponds to the evaluation stage of the DSRM, where an evaluation of the proposed method will is conducted. According to Pries-Heje et al. [81], evaluating an Information System depends on its' chronologic relationship to the artifact construction and its' environment. The evaluation timing can either be: ”ex ante”, if it occurs before the artifact is developed, or ”ex post”, if it takes place once the artifact exists. Regarding the evaluation environment, if it happens in a real-life setting, it is labeled naturalistic. However, it is labeled artificial if the evaluation is achieved through simulation, criteria-based analysis, or laboratory experiments.

The method developed as a result of this research proposal was evaluated according to its demonstration. Therefore, this evaluation is categorized as ”ex post” and naturalistic. Through the demonstration, the usefulness and effectiveness of the developed artifact were tested in a real-world scenario to verify if the proposed method is applicable in a realistic context.

A semi-structured interview was conducted with the Técnico+ business actors responsible for the processes evaluation (Chapter 5.4) to capture their assessment of the methods' results and their subsequent applicability to their RPA adoption.

In the conducted interview, after analyzing the results, as demonstrated in Table 5.7, the interviewees pointed out that it stood out that the presented results were adapted to their specific business goals, which was aligned with one of the main goals of using this method: adaptability. The highest-ranked business process (7.08) further demonstrated the aforementioned individual adaptability. Previous to developing this method, the organization had already proposed this process as a potential Proof of Concept. The interviewees also stated that, during process evaluation, the tables were filled according to the AS-IS business processes. Had there been the possibility to reengineer the business processes in order for them to achieve the same goals, the evaluation would have been different.

7

Conclusion

Contents

Robotic process automation is one of the emerging technologies drawing increasing interest for its' academic and business applications. However, there are still several challenges to its implementation, with the lack of frameworks and methods being one of them. This thesis proposes a method to select and prioritize processes suitable for automation based on multi-criteria decision-making techniques. The set of criteria used was based on a thorough literature review, and their weights were attributed according to case studies and research articles. The method application resulted in an ordered list of processes for automation according to their closeness to an optimal solution that was aligned with the related organization's vision.

7.1 Communication

This chapter is related to the last step of the DSRM, the communication phase. Two articles were submitted related to this dissertation:

1. "Robotic Process Automation (RPA) Adoption: A Systematic Literature Review" was accepted by Engineering Management in Production and Services (Q2 journal) published by De Gruyter Open Ltd.;

2. "A Method for Selecting Processes for Automation" was submitted to IEEE Access (Q1 journal) published by Institute of Electrical and Electronics Engineers Inc. and is waiting for a response.

Lastly, this dissertation report gathering the complete information regarding this topic was written and will be presented, discussed, and evaluated by a qualified jury, and will then be made available.

7.2 Limitations and Future Work

Despite the positive results obtained from the demonstration of this research, more empirical work is required to reveal how applicable this method is to different scenarios and organizational contexts.

While the method contributes to evaluating processes potential for automation, the results of the application of the method are still limited. Future research could consider validating the method using a quantitative research design of the results of automating the proposed processes.

Further, this technology is still very recent, and its research is still very restricted, consisting primarily of case studies. Therefore, researchers are invited to follow this technology and methods applicability as literature provides more knowledge on this technology adoption. This increase in available information may allow for a more complete, robust pair-wise comparison of criteria and improved alternative evaluation. Likewise, data science, recommender systems, and machine learning could also be used to explore new patterns and connections between criteria. Given that these methods require large amounts of data, which are not yet available, it was impossible to follow these paths in this research.

In our research, we limited the set of possible criteria to process characteristics. Studying how the sequentiality of processes may contribute to their suitability for automation is a possible future research direction. Furthermore, as with any multi-criteria decision-making method, AHP-TOPSIS has its limitations. Other MCDM techniques could be investigated as alternative methods for process selection.

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