

Robotic process automation: a comprehensive systematic literature review across industries, with a focus on healthcare

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Abstract

In today's world, where technological innovations are rapidly changing our understanding of business, processes and everyday life, it is not surprising that the concept of process automation is making significant strides forward. Robotic Automation Processes (RPA) is one such technology that revolutionizes the way we interact with routine tasks and business processes. The introduction of RPA in the healthcare sector promises to revolutionize processes related to administrative tasks, data processing and customer service. However, like any technology, RPA is not a universal solution and requires a deep understanding of its application, as well as awareness of potential risks and nuances. This review aims to present you with a variety of perspectives from researchers, experts and practitioners on the application of RPA technology in various fields of activity, with a focus on healthcare. Using the method of analysis and synthesis, we will consider various aspects of this technology, its advantages and limitations, as well as identify key trends and challenges facing those who seek to implement RPA in their activities. The results of this systematic review indicate a significant increase in researchers' interest in RPA technologies over the past ten years, peaking in 2023. This growth may be associated with increased attention to digital business transformation, process automation, and operations optimization.

Keywords

RPA (Robotic Process Automation), artificial intelligence, Industry 4.0, ILP (Integer Linear Programming), digital transformation, healthcare, pharmaceutical industry

1. Introduction

In our era of rapid technology development and rapid changes in business processes, understanding and applying innovations are becoming key success factors for organizations in all industries. One such innovation that is attracting increasing attention is the technology of robotic process automation (RPA) [1]. RPA is a set of tools and technologies that allow you to automate routine and repetitive tasks that were previously performed by humans.

The essence of RPA is to create virtual robots or software agents capable of emulating and performing human actions in information systems. These robots can perform a wide range of tasks, ranging from data processing and report generation to performing operations in business applications and CRM systems. However, unlike humans, RPA robots can work continuously 24/7 without fatigue, completing tasks with high accuracy and speed [2].

The relevance of RPA is explained not only by the potential benefits in increasing productivity and reducing costs, but also by the ability of the technology to adapt to various industries and activities [3]. As companies strive to optimize their business processes, RPA becomes an essential tool for achieving efficiency and competitiveness.

It should be noted that the development of RPA does not mean the replacement of human labor, but, on the contrary, allows employees to free themselves from monotonous tasks and direct their

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energy to more creative and strategic work. Thus, RPA contributes not only to improving processes, but also to increasing employee and customer satisfaction.

In this article, we will attempt to highlight various aspects of RPA technology, starting with a review of previous research in this area [4] and ending with its application in various fields, including healthcare. We will also look at the main challenges and challenges facing the implementation of RPA and trace the ways it can be successfully used in various contexts. As a result, the reader will gain a deep understanding of how RPA can change the way organizations work and provide new opportunities for development and innovation.

2. Related works

In recent decades, robotic process automation (RPA) has become one of the key areas in the field of digital transformation of organizations. This innovative technology is the automation of routine and repetitive tasks using virtual robots or software agents, which significantly optimizes business processes and increases productivity.

The essence of RPA is that it is able to automate a wide range of operations that previously required human intervention. These can be tasks such as data collection, information processing, data entry into systems, as well as performing standard operations in software applications. It is important to note that RPA works at the user interface level, which makes it flexible and easily implemented into various types of systems without the need to change the existing infrastructure.

One of the key advantages of RPA is its ability to perform tasks with a high degree of accuracy and speed, which allows organizations to significantly reduce the time required to complete operations and minimize the risk of errors. In addition, by automating repetitive tasks, employees can free themselves from monotonous and routine responsibilities and focus on more strategically important tasks.

Thus, robotic process automation is a powerful tool for improving the efficiency of business processes, reducing operating costs and improving the quality of work of organizations as a whole.

Having analyzed the relevant literature, we strive to identify key trends, challenges and prospects for the development of RPA in the modern world. Our review includes the work of leading researchers and practitioners, as well as up-to-date data and statistics collected from leading scientific databases such as Scopus.

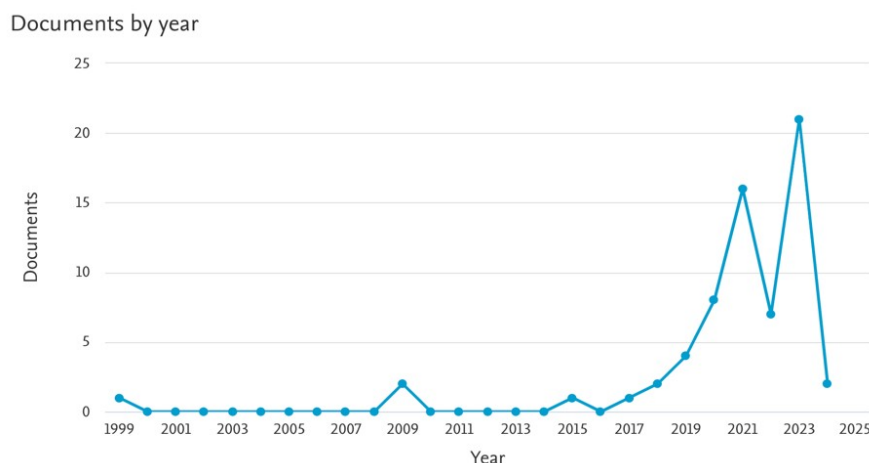


Figure 1: Number of publications by year on the use of RPA.

The graph "Number of publications on the use of RPA from 1999 to 2024" (Fig.1) is a visualization of the growth dynamics of scientific publications on the use of robotic process automation (RPA) in the period from 1999 to 2024. The data for the graph were collected from the unified bibliographic and

abstract database of peer-reviewed scientific literature Scopus, which is one of the leading sources of scientific information.

The analysis of the graph allows us to draw the following conclusions:

Increase in the number of publications: According to data from the Scopus database, the number of articles on the use of RPA is rapidly increasing over time. This growth can be characterized as a geometric progression, which indicates the significant interest of the scientific community in this topic.

The importance of RPA in scientific research: The increase in the number of publications indicates the importance and relevance of the topic of robotic process automation in the scientific environment. This indicates a wide range of research interests and a variety of issues considered in the context of RPA application.

Scopus Information Base: The data for the graph were obtained from the Scopus database, which is one of the largest and most authoritative bibliographic databases for scientific publications. Thus, the graph reflects the general thematic dynamics of RPA research in the scientific community.

One of the significant sources highlighting the trends in the development of RPA since its inception is the work of Aguirre and co-authors [5]. The research by Aguirre and Rodriguez presents a case study on business process automation using RPA. They describe in detail the methodology of implementation and the results of automation, demonstrating the advantages of this technology in practical application. The work draws attention to the importance of choosing the right processes for automation and the need to train personnel to work with robotic processes.

Analyzing articles [6], [7] and [8], it is possible to emphasize the relevance and importance of robotic process automation (RPA) in the context of digital transformation of organizations. The work by Madakam, Holmukhe and Jaiswal (2019) entitled "The future digital work force: robotic process automation (RPA)" notes that RPA plays a key role in shaping the future digital work potential. This is supported by a study by Van der Aalst, Bichler and Heinzl (2018), who discuss the importance of RPA in the business environment and information systems.

An article by Hofmann, Samp and Urbach (2020) titled "Robotic process automation" [8] also highlights the impact of RPA on electronic markets. This indicates the wide range of applications of RPA and its importance in various fields of activity, which confirms the relevance of studying this technology.

Thus, based on these articles, it can be argued that RPA is a key element of digital transformation and has a high degree of relevance for modern organizations, which is confirmed by research in this area.

The article by Ribeiro and co-authors (2021) [9] provides an extensive review of the literature on the application of robotic process automation (RPA) and artificial intelligence in Industry 4.0. This review allows us to identify current trends and directions of RPA development, as well as forecasts of its impact on the industry. The article provides valuable insight into how RPA is being integrated into the context of the Fourth Industrial Revolution and what benefits it can bring to organizations.

On the other hand, the article by Alberth and Mattern (2017) "Understanding robotic process automation (RPA)" [10] provides a more basic introduction to RPA technology. It focuses on explaining the basic concepts and principles of RPA, as well as its application in the financial sector. This article serves as an excellent starting point for understanding the basics of RPA and its potential application in specific business areas.

Thus, both articles contribute to the understanding of RPA technology, but each of them has its own specifics: the article [9] reviews the technology in the context of industry 4.0, while the article [10] provides a deeper understanding of the basic aspects of RPA.

The research presented in the reviewed articles allows us to form a complete picture of the significance and prospects for the development of robotic process automation (RPA). The robotization of processes based on algorithms and artificial intelligence is becoming an important tool for the digital transformation of organizations in various industries. The authors emphasize the benefits of implementing RPA, such as increased productivity, reduced costs and improved quality of work.

The article [11] by William and colleagues (2023) presents the evolution of RPA and artificial intelligence in the context of Industry 4.0. It examines in more depth the development of these technologies from the time of the first steps of the industrial revolution 4.0 to modern trends. The authors analyze how RPA and artificial intelligence have been applied and continue to develop within Industry 4.0, and attempt to predict their future direction.

Based on a comparison of articles [9] and [11], it can be concluded that both of them emphasize the importance and prospects of using robotic process automation (RPA) and artificial intelligence in the context of the industrial revolution 4.0. However, each of the articles has its own unique contribution.

A systematic review of the literature on RPA adoption [12] has revealed that the successful implementation of this technology depends on a number of factors, such as staff training, understanding of business processes and choosing the right supplier.

Research on the development of RPA for business process management integration shows that this technology can significantly improve the effectiveness of long-term business process management, especially in the context of a rapidly changing business environment [13].

An introduction to the intelligent automation framework using AI and RPA demonstrates how a combination of these technologies can make processes more flexible, adaptive and intelligent, which helps to increase productivity and optimize business processes [14].

Process robotics (RPA) has become an integral part of the digital transformation strategy for many organizations. This technology allows you to automate routine business processes, freeing employees from monotonous operations and increasing the overall efficiency of the organization.

Research conducted in this area [15] confirms that the successful implementation of RPA requires a thorough analysis of the company's needs. Each organization has its own unique processes and tasks that must be considered when configuring and adapting RPA technology.

Optimization of RPA [16] requires a deep understanding of business processes. This includes analyzing current work flows, identifying bottlenecks, and identifying points for automation. It is only through a systematic and consistent approach that effective RPA implementation and achievement of the set goals can be achieved.

The use of RPA in accounting [15] can significantly improve the efficiency and accuracy of tasks. Automation of routine operations allows you to reduce time costs, reduce the risk of errors and improve the quality of work.

However, for successful optimization using RPA [17], it is necessary not only to possess technical skills, but also to understand the specifics of business processes. It is also important to adapt the culture of the organization to new technologies in order to ensure smooth implementation and maximum efficiency of the use of RPA.

Process robotization (RPA) using the formulation of integer linear programming is a methodology presented in [18] that allows you to automate business processes using a mathematical approach. This methodology uses integer linear programming to optimize the sequence and execution of tasks.

Integer linear programming (ILP) is a mathematical programming method that solves optimization problems where variables are integers. In the context of RPA, ILP is used to determine the optimal sequence of actions for automating processes, taking into account the limitations and goals of business processes.

The use of ILP in RPA allows you to formally describe business processes and transform them into a mathematical model, which is then solved using optimization algorithms. This allows you to automatically optimize the execution of processes, minimizing the time spent on their execution and reducing the likelihood of errors.

Thus, the RPA methodology using the formulation of integer linear programming is an innovative approach to business process automation that can be effectively applied to increase productivity and optimize the operational activities of organizations.

3. Problem statement

RPA is a key technology that solves important tasks of automating routine and administrative processes in various industries. One of the main problems faced by organizations, including medical institutions, is the significant number of routine operations such as data management, document processing and administrative tasks. In healthcare, this manifests itself in processes such as patient registration, medical records management and insurance claims processing, which takes up significant resources from medical staff and reduces overall productivity [2].

In addition, the problem of human error is particularly relevant in healthcare and other industries where data accuracy and reliability are crucial. Automation of these processes using RPA not only reduces the likelihood of errors, but also increases overall work efficiency [3]. For example, automation of routine tasks in medicine, such as filling out medical forms and processing insurance claims, improves the quality of service and reduces risks for organizations.

In addition, in all industries, automation using RPA significantly speeds up the execution of tasks, which leads to an increase in overall productivity and a reduction in time for routine operations [9]. This is especially important in the context of digital transformation, where RPA plays an important role in optimizing business processes and reducing operating costs, both in medicine and in other fields [12].

However, the implementation of RPA in various industries faces challenges such as integration with existing systems, the need for staff training and data security. These issues require a careful approach to RPA planning and implementation in any industry, especially in healthcare, where patient data protection is critical [19].

Thus, RPA solves a number of key tasks in various industries, from increasing productivity to minimizing errors, while automating processes in healthcare stands out as one of the key areas for further research and implementation. Successful implementation of the RPA requires consideration of integration, staff training and data security.

4. The use of RPA in various fields of activity

In addition to these fields of activity, RPA also finds applications in manufacturing, telecommunications, information technology, engineering, research and development, as well as in many other fields.

In today's world, technology plays a key role in everyday life as well as in the business environment. With a constant commitment to improving efficiency and optimizing processes, organizations are turning to innovative solutions such as process robotics (RPA). This technology offers organizations the opportunity to automate routine tasks, freeing up human resources for more strategically important tasks.

In this part of the article, we will turn to the various fields of activity in which RPA technology is used. Let's look at how it is used in various industries, ranging from accounting and auditing, to logistics, education and business process management. We will also look at the challenges and advantages that organizations face when implementing RPA technology, as well as explore the prospects for its further development.

According to data from the Scopus database (Fig.2), most of the articles on RPA relate to computer science (27.4%), engineering (17.8%) and business and management (7.5%) [Other (10.3%); Social Sciences (2.1%); Environmental Sciences (2.7%); Physics and Astronomy (3.4%); Economics, Econometrics and Finance (3.4%); Energy (4.8%); Decision Sciences (10.3%); Mathematics (10.3%)]. This indicates the wide range of applications of RPA in various fields and its significant importance for modern organizations and society as a whole.

Documents by subject area

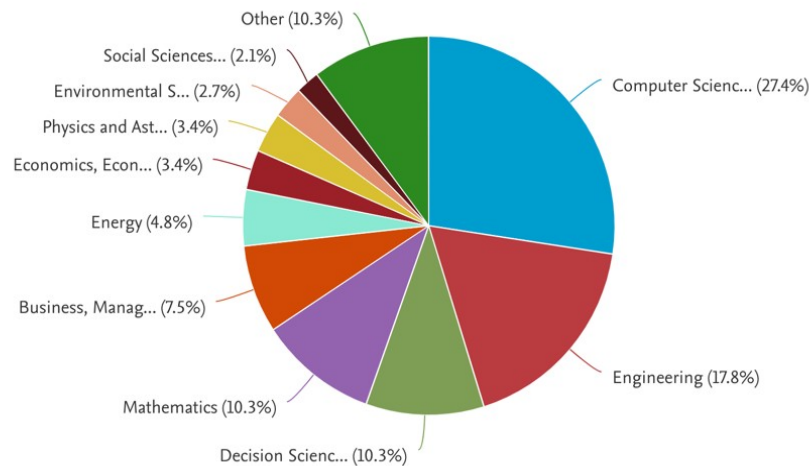


Figure 2: Various fields of activity in RPA in various publications.

Process robotics (RPA) is actively used in various fields of activity, including accounting, healthcare, education, logistics, warehouse management, data processing and many others.

In accounting and financial reporting, RPA is used to automate accounting processes, financial data analysis, reporting, and routine tasks such as account processing and budget management [15, 21]. This allows you to increase the efficiency of accounting departments and reduce the likelihood of errors.

In healthcare, RPA is used to optimize administrative processes, automate filling out medical forms, manage medical documentation, as well as analyze medical data and manage patient data [20]. This makes it possible to improve access to medical services, reduce waiting times and improve the quality of medical care.

In the field of accounting and auditing, RPA has become an essential tool for automating routine tasks such as financial data processing, reporting and verifying financial transactions. It allows you to reduce the time required to complete these tasks and reduce the likelihood of errors, improving the accuracy of financial reports and ensuring compliance with legal requirements [21].

In business, RPA has a significant impact on organizational efficiency and productivity. It allows you to automate business processes, speeding up the completion of tasks and reducing labor costs. In addition, RPA helps to optimize operations and increase business flexibility, which in turn contributes to its competitiveness in the market [22].

Thus, in various fields of activity, including accounting, auditing, and business, RPA is an effective tool for automating routine tasks, optimizing processes and increasing operational efficiency.

In logistics and warehouse management, RPA is used to optimize the processes of inventory management, supply tracking, cargo routing and automation of warehouse operations [23, 24]. This allows you to reduce logistics costs, increase the speed of order processing and improve the accuracy of delivery.

In education, RPA is used to automate the processes of managing educational materials, registering students, conducting administrative procedures and creating personalized educational programs [25, 26]. This contributes to improving the efficiency of educational institutions and improving the quality of education.

In the article "Evolution of business organizations: analysis of process robotization", the author examines the progressive introduction of process robotization into modern organizations. He draws attention to the fact that business organizations are actively implementing RPA technologies to optimize their business processes and improve operational efficiency. The author analyzes the

evolution of the business structure under the influence of RPA and identifies the key advantages and challenges that companies face when implementing this technology [22].

In another article, "Integrating Process Robotics into Business Process Management," the authors explore the integration of RPA into business process management. They discuss RPA integration methods and strategies based on modern business process management practices. As a result of the study, the authors conclude that successful RPA integration requires an integrated approach, including technical expertise, understanding of business processes and strategic planning [27].

In addition to these fields of activity, RPA also finds applications in manufacturing, telecommunications, information technology, engineering, research and development, as well as in many other fields.

However, despite the significant advantages, each industry faces unique challenges in implementing RPA, which can make it difficult to realize its potential.

Healthcare: In the medical field, one of the main challenges is the integration of RPA with electronic medical records (EMR). Medical systems often vary in their architecture, and setting up RPA to work properly with these systems takes time and resources. In addition, training of medical personnel to work with automated processes is necessary to minimize errors and improve work efficiency. Patient data security issues also remain at the forefront, as information must be protected from leaks and unauthorized access.

The financial sector: In financial institutions, RPA is used to automate processes such as transaction processing and account management. The main problem here is integration with internal systems such as risk management systems and payment systems. Financial institutions must also ensure a high level of data security in order to comply with regulatory requirements and prevent the leakage of confidential information.

The manufacturing sector: In manufacturing companies, integrating RPA with existing manufacturing execution system (MES) can be difficult due to differences in data and how systems interact. The need for staff training and ensuring cybersecurity in the production environment are becoming important aspects of successful automation integration.

5. The use of RPA in healthcare

The introduction of process robotics (RPA) in the healthcare sector plays a significant role in optimizing and improving the quality of medical services. Here are a few key reasons why RPA is important and necessary in healthcare:

Process optimization: In the medical field, there are many routine tasks such as filling out documentation, processing insurance claims, and managing medical records that can be automated using RPA. This allows healthcare professionals to focus on more important aspects of their work, such as patient care and the development of treatment strategies.

Improving the quality of services: Automation of routine allows you to improve the accuracy and reliability of tasks. This is especially important in the medical field, where even the slightest mistakes can have serious consequences for patients. Robotic processes ensure more accurate and consistent task execution, which contributes to improving the quality of medical care.

Reducing time costs and improving accessibility: The implementation of RPA reduces the time spent on routine operations such as processing medical records or preparing reports. This not only improves the efficiency of healthcare staff, but also increases the availability of medical services to patients, reducing waiting times and improving the speed of service.

Cost reduction and increased economic efficiency: Routine automation reduces operational costs by reducing human labor, reducing errors and increasing productivity. This helps healthcare organizations reduce costs and optimize budgets.

Improved data management and regulatory compliance: RPA ensures automatic compliance with standards and regulations in the processing of medical data, which helps reduce the risk of errors and ensure compliance with the requirements of legislation on the confidentiality and security of patient data.

Information from the Scopus database shows that the number of articles on the use of process robotics (RPA) in healthcare is limited (Fig.3). Despite this, significant interest in this topic remains in various fields, including chemical engineering, medical specialties, materials science, pharmacology, toxicology and pharmacy.

Other

- Chemical Engineering - 2 documents
- Health Professions - 2 documents
- Materials Science - 2 documents
- Medicine - 2 documents
- Pharmacology, Toxicology and Pharmaceutics - 2 documents
- Agricultural and Biological Sciences - 1 documents
- Arts and Humanities - 1 documents
- Biochemistry, Genetics and Molecular Biology - 1 documents
- Earth and Planetary Sciences - 1 documents
- Psychology - 1 documents

Figure 3: Publications related to healthcare and RPA.

The limited number of articles in these areas can be explained by the fact that the application of RPA in healthcare is still relatively new and requires further research and study. However, there are a number of potential applications of RPA that can significantly improve the quality and effectiveness of medical services.

In medical specialties such as surgery, oncology, and cardiology, RPA can be used to automate routine tasks such as analyzing medical data, preparing reports, and managing patient medical records. This will allow medical staff to focus on more important aspects of their work, such as diagnosis and treatment.

In agricultural and biological sciences, RPA can be used to automate plant and animal care processes, as well as to analyze data on diseases and parasites. This helps agricultural workers to increase yields and reduce costs.

Pharmacology, toxicology and pharmacy can also benefit from the use of RPA. Automation of processes and data analysis can help pharmacists and researchers in the field of developing new drugs and therapeutic methods.

Thus, despite the limited number of articles on the use of RPA in healthcare, the potential of this technology in this area is huge. Further research and development in this area can lead to significant improvements in the quality and effectiveness of medical services.

From the analysis of these articles [20], [28] and [29] devoted to the application of process robotics (RPA) in healthcare and the pharmaceutical industry, the following conclusions can be drawn:

Implementation of RPA in healthcare: Articles [20] and [28] highlight the significant potential of RPA to improve the effectiveness and quality of medical practice. RPA can be applied to automate routine operations in medical institutions, such as medical data processing, medical records and accounts management, as well as to optimize patient management processes. This reduces the time spent by medical personnel on administrative tasks and improves the quality of patient care.

Application of RPA in the pharmaceutical industry: Article [29] discusses the role of RPA in the pharmaceutical industry. RPA can be used to automate drug manufacturing processes, inventory management and supply tracking, as well as to process clinical trial data. This allows pharmaceutical companies to increase production efficiency, reduce time costs and improve data accuracy.

Potential for further research: Despite the importance of the application of RPA in the healthcare and pharmaceutical industries, the articles indicate the need for further research and development in

this area. It is important to continue exploring the potential of RPA to optimize business processes and improve the quality of services in healthcare and pharmaceuticals.

Specific examples of the use of RPA in the medical field illustrate the significant advantages of this technology.

1. Automation of the patient admission process:

RPA can be used to automate the collection and processing of patient data when making an appointment or hospitalization. For example, when recording a patient, the RPA system can automatically extract information from an electronic medical record (EMR), compare it with the database of insurers, check the relevance of the policy and compare it with the schedule of doctors. This significantly reduces the time spent on manual processing and reduces the burden on medical staff.

2. Clinical workflow management:

In large medical institutions, RPA can be used to automate the management of clinical processes. For example, robots can automatically distribute tasks among medical staff based on data on the number of patients, workload of departments and work schedules. This increases the efficiency of workflow management, speeds up patient care and improves coordination between different departments.

3. Processing of insurance claims:

One of the time-consuming processes in medical institutions is the filing of insurance claims. RPA can automatically collect patient data, fill out insurance application forms and send them for further processing. This reduces the likelihood of errors related to the human factor and speeds up the process of receiving insurance payments, which helps medical institutions to receive payment for services rendered faster.

4. Processing of laboratory data:

In the laboratory, RPA can automatically process test results and transmit them to doctors. For example, the robot can collect data from laboratory devices, enter the results into electronic medical records of patients and notify doctors when the results are ready. This reduces the waiting time for analyses and increases the accuracy of data processing.

5. Medical Documentation Management:

RPA can help automate the management of medical records by automatically updating and archiving patient data. This is especially important when processing large amounts of information, which reduces the risk of data loss and speeds up access to important medical information for doctors and staff.

Thus, these articles highlight the importance and potential of RPA applications in the healthcare and pharmaceutical industries, as well as the need for further research and development in this area to maximize the benefits of using this technology.

6. Conclusion

RPA is an innovative approach to automating every day and routine tasks using virtual robots or software agents. An analysis of 29 sources on RPA technology makes it clear that this technology plays a key role in digitalizing organizations and optimizing their business processes. A study of the relevant literature shows that RPA has found wide application in many industries, ranging from accounting, finance and logistics, to healthcare, education and the pharmaceutical industry.

It is important to note that each of these areas of activity has its own characteristics and requirements regarding the implementation of RPA. For example, in accounting and finance, RPA can significantly improve the efficiency and accuracy of operations, reducing time and error risks. In logistics and warehousing, RPA is able to optimize inventory management and delivery processes, reducing time costs and improving overall productivity.

In healthcare, RPA can lead to automation of many administrative tasks, such as managing medical records, maintaining appointment schedules, and accounting for medical expenses. This reduces the burden on staff and focuses their efforts on more important aspects of medical care.

Despite all the advantages, the implementation of RPA also faces certain obstacles and challenges. Some of these include the difficulty of integrating with existing systems, the need for staff training, and the regulation of data security issues.

Research in the field of RPA and its application in various fields of activity continues, which allows us to deepen our understanding of the technology and develop effective strategies for its implementation. Thus, RPA is a powerful tool that can significantly improve the processes and results of organizations in many sectors of the economy.

Additionally, research shows that RPA not only improves the efficiency of business processes, but also helps to reduce transaction costs and increase the competitiveness of companies. This technology allows you to automate many routine tasks, freeing up employees' time to perform more creative and strategically important tasks.

An important point is also that RPA can be successfully integrated into existing information systems of organizations, which allows it to be used as an additional tool for optimizing processes without the need for a radical revision of the business structure.

Successful implementation of RPA requires addressing several key challenges. Firstly, integration with existing systems such as CRM, ERP and EMR in healthcare requires careful analysis and planning to avoid disruptions in operations. Secondly, staff training is critical for an effective transition to automated processes, minimizing errors and increasing productivity. Finally, ensuring data security is especially important in industries where privacy is critical, such as healthcare and finance. Integration, staff training and data protection issues must be taken into account for the successful implementation of RPA.

Despite the fact that RPA has huge potential and brings significant benefits, the successful implementation and use of this technology requires careful planning, adaptation of the organization's culture, as well as staff training. Effective use of RPA is possible only if the organization fully understands its needs and adapts the technology to its unique business processes.

Thus, RPA is a modern and powerful tool for improving the efficiency and competitiveness of organizations in various industries, and its role in digitalization and optimization of business processes will continue to grow in the future.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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