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TOPICAL REVIEW

AI-Enhanced Robotic Process Automation: A Review of Intelligent Automation Innovations

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ABSTRACT The rapid technological growth in recent decades due to the integration of robust technologies and automation have led to the rise of digital services and the emergence of Industry 4.0. This paper explores the concept and potential of AI-powered intelligent automation based on the synergistic use of Robotic Process Automation (RPA) and Artificial Intelligence (AI) to enhance organizational and business processes across various sectors. RPA automates routine, rules-based tasks, thereby allowing human workers to engage in more innovative activities. When integrated with AI, RPA systems gain the capacity to analyze data, identify patterns, classify information and forecast which leads to significant improvement in accuracy and productivity. This literature review investigates the current state of RPA and AI integration while highlighting its applications in different sectors such as manufacturing, agriculture, healthcare, finance, and retail. Along with discussing the drawbacks and restrictions, such as technological issues and moral dilemmas, this paper also discusses the advantages of this integration, which include decreased costs, increased output, and simplified operations. By leveraging AI techniques such as classification, text mining of neural network, RPA technologies optimize business operations and advance Industry 4.0. This study also illustrates the challenges and limitations of this integration such as technical difficulties and ethical considerations. The aim of this review is to provide a comprehensive understanding of the synergistic potential of RPA and AI while offering insights into their contribution in shaping the future of intelligent automation.

INDEX TERMS Artificial intelligence (AI), business process, intelligent process automation (IPA), robotic process automation (RPA).

I. INTRODUCTION

The rapid advancement of technology over the past years has, in many ways, introduced a new wave of digital transformations that are now changing what, how, and with whom organizations work and compete worldwide. At its core is an integration largely driven by advanced automation technologies forming this new era—a reshaping of business and competition—called Industry 4.0. At the core of this revolution, there is Robotic Process Automation and Artificial Intelligence—two complementary technologies that, when combined, unleash extraordinary potential to improve business processes, boost productivity, and trim operational costs.

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Robotic Process Automation (RPA) is a new technology that allows one to easily automate such routine and rules-based tasks performed by humans. Such tasks can include repetitive actions—for instance, data entry, moving files, and a number of other back-office tasks. The use of the RPA bots enables one to do mundane, repetitive tasks much faster than a human being can do them, with precision, thus reducing errors and greatly increasing productivity. They lack the cognitive ability compared to AI; they simply follow a set of pre-defined rules and are used in operations that require zero to very little human judgment. According to a Grand View Research, the RPA market is poised to have a compound growth rate (CAGR) of more than 40% to \$25 billion in 2027 [1]. With its aptitude in cost-saving, error reduction, and business process improvement, it has resulted in increased levels of deployment by different business concerns.

However, it is when RPA gets combined with Artificial Intelligence that its true potential comes out because AI gives the process of automation cognitive abilities. The key activities in which AI is associated are those that require human-like intelligence, including data analytics, pattern recognition, and decision-making. By adding AI to RPA, companies can upscale their automating operations into complex ones that are out of reach for ordinary RPA. This brings in the combination of Intelligent Process Automation (IPA), which offers firms a strong tool for automating simple and complex activities. It does not just automate repetitive processes; rather, thanks to AI's learning and adaptive properties, it brings about enhanced improvements in terms of accuracy, productivity, and innovation across a wide range of sectors [2].

The popularity of both RPA and AI increases each year, and the rate at which enterprises deploy them is increasing in industries that seek digitization. In earlier days, automation used to be a huge activity made possible by only a few very skilled professionals who built and deployed large automation systems. Today, the integration of AI with RPA has enabled the development of lean end-to-end business processes such that companies can innovate and bring about revolution in workplace practices. Most industries have started infusing artificial intelligence into advanced technologies to drive the power of digital automation in improving both operational efficiencies and customer experiences.

Throughout this paper, we will explore the evolution of RPA, how it has moved from mere automation to becoming an important feature in contemporary business processes. We will then delve into how AI is integrated with RPA so that we understand how the synergy between these two technologies enhances the capabilities of automation systems and permits more complex and intelligent operations. The paper will also cover widely used tools that provide the platform for integration for both RPA and AI, among others, including UiPath, Kofax, Automation Anywhere, and Blue Prism.

We will provide an in-depth analysis of the application of AI-driven RPA across the following sectors:

Finance and Banking: AI-powered RPA automates loan processing, increases fraud detection with automated credit checking, and offers improved customer service. Further, challenges of data security, compliance, and integration will also be discussed.

Auditing: The efficiency and accuracy of the process in the audit industry are improved by AI-based RPA, and it reduces the likelihood of human error, allowing one to continue monitoring financial activities. We discuss specific use cases and the associated challenges here, which include large volumes of data and maintaining transparency in AI-driven decisions.

Medical and Health Services: Health, too, has been one of the beneficiaries. Use of AI-enabled RPA in managing details of patients, automation of administrative functions, and other diagnostic-related processes have become easier. The problems related to this industry, including data privacy problems and ethical issues of AI in healthcare, are discussed in the following sections of this paper.

Recruitment Industry: The recruitment industry uses AI for resume screening, ranking, and interview scheduling activities. We will also discuss issues related to the bias of AI models and transparency in automated decisions.

Manufacturing: How AI-based RPA is utilizing automation to optimize production processes, supply chain management, and quality control in the manufacturing space. Discussion will cover the challenges in integrating AI with current manufacturing systems and complexities in managing industrial operations.

Back Office Operations: The paper has provided a business case of a real AI-powered RPA project for back-office operations, explaining how the RPA can be put in place without disturbing the existing systems. The section then discusses technical challenges of AI-RPA integration in data-intensive environments.

Furthermore, we will discuss challenges and limitations in the implementation of AI-powered RPA, such as technical complexity, integration problems, data privacy concerns, and ethical considerations [3]. Overcoming such problems needs effective planning and well-prepared governance with a commitment to continuous learning and improvement.

Finally, the paper will explore open challenges for research regarding the context of AI-powered RPA. Among other subjects, it will address change management, ethical and legal considerations, model selection for machine learning, and process explainability within the AI-driven process. We will also examine the potential for Intelligent Process Automation in sectors that are still in the early stages of digital transformation, such as agriculture.

This paper aims to offer a comprehensive review of AI-powered RPA systems across multiple industries as mentioned above. The workflow of our study is presented in Figure 1. Unlike many recent literature reviews that focus narrowly on a single domain or technology (either RPA or AI), as summarized in Table 1, this paper integrates findings from diverse areas, providing a holistic perspective. Additionally, it examines the latest advancements and features of AI in leading RPA tools such as UiPath, Kofax, Automation Anywhere and Blue Prism, detailing how AI enhances their capabilities. By investigating AI-enhanced RPA systems across various industries, this study consolidates existing knowledge, highlights detailed use cases, identifies challenges and gaps in the existing systems, and proposes future directions for integrating AI into RPA. Furthermore, this paper also proposes an AI powered RPA based framework that can be beneficial to the agricultural sector, an area that, to the best of our knowledge, has not been explored in existing studies.

TABLE 1. A summary of the review papers focused on RPA and AI based systems.

Paper	Contribution
[4]	This paper attempts to focus on the theoretical and practical challenges in combining RPA and AI regardless of any industry or area based on scholarly literature review and an interview study.
[5]	Authors here provide an in-depth exploration of RPA, addresses the gap in guiding organizations on how to identify processes for automation. The paper also examines the use of RPA across various business organizations and discusses its future potential.
[6]	This study presents theoretical and practical applications of AI, AI-based RPA and RPA in various industries and organizations. They enlisted some ways on how to choose RPA and AI technologies that align with the requirements of companies. Although this paper touches on various AI-based RPA techniques and RPA tools, it didn't provide an depth analysis.
[7]	This paper explores potential IPA and AI challenges. They also presents a brief summary of the papers presented at the AAAI 2020 workshop on Intelligent Process Automation, aiming to motivate researchers from RPA and AI community to explore research ideas that combines these two technologies.
[8]	The authors here reviewed studies exploring the integration of AI and RPA, emphasizing potential benefits such as enhanced operational efficiency and adaptability to increasing market demands. Additionally, they propose a model designed to balance the social and environmental impacts that may result from the adoption of these technologies
[9]	The contribution of this paper is to highlight the key aspects of RPA and review its application in the healthcare domain. It emphasizes RPA's potential in healthcare domain.
[10]	This paper explores the potential of RPA in the financial and insurance industries by focusing on its advantages. It highlights implementation challenges and discusses how advancements in AI could bring significant future benefits particularly in the insurance industry.
[11]	This paper focuses on how AI and RPA can transform the banking industry by addressing key challenges like fraud detection, customer experience and operational inefficiencies. It highlights how AI with RPA can streamline processes in the banking industry.
[12]	The authors of this paper attempt to provide an understanding of RPA as a transformative technology. It also highlights guidelines for automation, outlines challenges, and addresses the human impact of RPA adoption.
[13]	The purpose of this analysis is to gather data and research on the use of RPA, incorporating machine learning and deep learning techniques, to develop more effective and suitable methods for application in people management while addressing complex public sector legislation requirements on its servers.
[14]	This paper explores the transformative role of AI and RPA in shaping smart cities and environments. It discusses the ways for advancements like 5G and future 6G technologies. Additionally, it outlines frameworks, such as RPA life cycles and AI-driven solutions, for addressing challenges in urban environments and improving digital infrastructure.

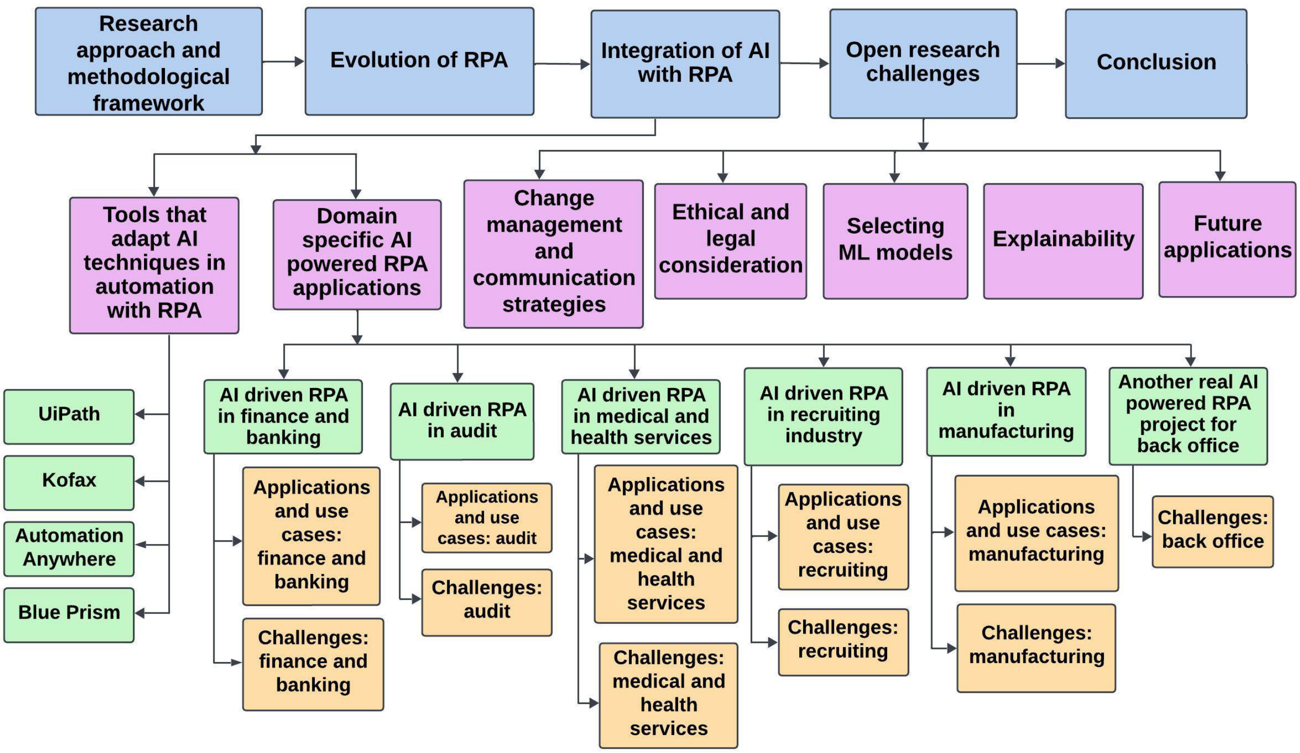

FIGURE 1. Workflow of AI-enhanced RPA study.

II. ORGANIZATION OF THE PAPER

The organization of this paper follows a logical structure to comprehensively address the goal of our study. The next section,The Research Approach and Methodological Framework (III) describes the systematic methodology used in this study to investigate recent AI-powered RPA systems. The Evolution of Robotic Process Automation(RPA) (IV) provides the history of RPA and how it has evolved

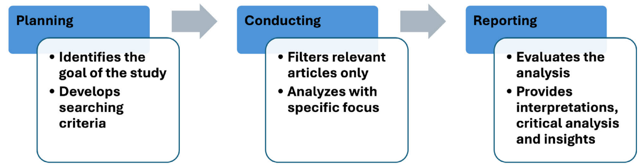

FIGURE 2. Research procedure.

over the past few years. The Integration of AI with RPA (V) section explores how AI enhances RPA systems for greater adaptability and efficiency. The Tools That Adapt AI Techniques in RPA Automation (VI) section provides insights into platforms such as UiPath, Kofax, Automation Anywhere and Blue Prism, showcasing their AI-driven features. The following sections focus on domain-specific applications: AI-Driven RPA in Finance and Banking (VII), Audit (VIII), Medical and Health Services (IX), Recruiting Industry (X) and Manufacturing (XI). Each domain includes subsections on applications, use cases and challenges. The study also highlights Another Real AI-Powered RPA Project(XII) for Back Office, detailing its associated challenges. The Open Research Challenges section discusses (XIII) critical issues such as change management, communication strategies, ethical and legal considerations, selecting machine learning models, explainability, and future applications. Finally, the Conclusion (XIV) synthesizes the findings and proposes directions for future research.

III. RESEARCH APPROACH AND METHODOLOGICAL FRAMEWORK

This paper adopts a literature review approach inspired by the Systematic Literature Review (SLR) methodology, which is structured into three distinct phases: planning, conducting, and reporting as shown in Figure 2. In the planning phase, we identified the necessity for this study (as outlined above) and developed a comprehensive search protocol that includes inclusion/exclusion criteria. For identifying relevant articles, we applied these criteria using Google Scholar and reputable databases such as IEEE Xplore and SpringerLink. The search process was guided by two specific keywords: "RPA" and "AI." The initial selection involved screening titles to evaluate their relevance against predefined inclusion criteria, followed by a detailed review of abstracts. Articles passing these stages were further checked for full-text accessibility. In the conducting phase, we systematically curated a final set of articles for review. These articles were analyzed with a specific focus on methodologies related to RPA and AI. Finally, in the reporting phase, we synthesized the findings, providing our interpretations, critical analyses and insights into the reviewed literature [15].

IV. EVOLUTION OF ROBOTIC PROCESS AUTOMATION (RPA)

As mentioned before, the RPA market is projected to reach $25 billion by 2027, with a CAGR of over 40%. And, USA alone will exceed $12B by 2028, with a CAGR growth of

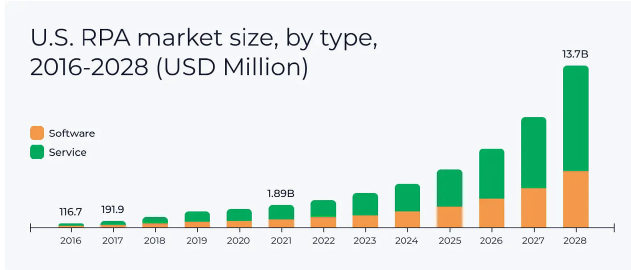

FIGURE 3. U.S RPA market size analysis by year [17].

32.8%. The growth is largely fueled by RPA service models, with the RPA-as-a-service segment capturing over 61% of the market share in 2022 and experiencing the fastest growth rate [16]. Figure 3 illustrates a market analysis or RPA.

The growth reflects the widespread recognition of RPA and its potential in different industries where automation can provide with transformational benefit [7].

RPA has a rich history that started from the early days of computing and automation in 1990s. It emerged with the use of screen scraping and workflow automation software. These technologies allowed the automation of repetitive tasks by capturing data from graphical user interface (GUI). The concept got more recognized when organization started adopting automation in their business process automation altering their IT infrastructure [17]. The term "Robotic Process Automation" was addressed as a separate automation category in the automation industry in 2010. The early adoption of RPA started with the use of automating simple, rule-based tasks.

Around 2012, companies like Blue Prism, Automation Anywhere and UiPath appeared to be as leading vendors that provides platform to design business automation processes [17]. The RPA market started to gain recognition for its potential of cost saving and operational efficiency during the year between 2013 and 2015 [18]. Gradually the adoption flowed across different industries such as financial, healthcare, manufacturing and so on. The flexibility of deploying RPA played a significant role into the growth of RPA.

During 2017, businesses started to publish report on high returns on investment (ROI) from their automation processes. Gradually, RPA's evolution started to be advanced by the introduction of AI technologies which began enhancing the potential of RPA and leaded towards IPA [19]. That's when UiPAth, Automation Anywhere, Blue Prism and other vendors started to receive funds to accelerate the development of RPA by integrating AI technologies. This advancement and integration of AI and RPA allowed bots to handle unstructured data and make complex predictive decisions. This development made significant shift in the automation industry during 2019 [20]. The COVID-19 accelerated the digital transformation across the organization with the need of maintaining social distancing [21]. [22] investigates the use of emerging RPA and AI in mitigating the negative impacts of the COVID-19 pandemic on the global economy and public health. It explores how these technologies can be applied across various industries to effectively manage the challenges posed by the pandemic.

For the last two to three years, RPA has become a mainstream technology as large enterprises and government agencies are implementing it to improve their operational efficiency and reduce costs. The focus shifted towards other technologies such as, cloud computing. As the need of RPA with cognitive power is increasing the vendors are offering more advanced features with flexibility of selecting AI technologies and deploying RPA models into cloud. This is how the evolution or RPA from performing simple tasks to do complex and sophisticated tasks has reshaped industries and their business processes globally. In our next section we will talk about this integration in details.

V. INTEGRATION OF ARTIFICIAL INTELLIGENCE (AI) WITH RPA

In today's world, AI algorithms and Machine learning(ML) techniques has been implemented in almost all sectors where digital transformation is introduced. ML is used to train machine how to deal with large dataset efficiently. By using AI techniques, it is possible to explore data, get deep insight from the data, extract information, analyze and predict future trends. Having these scopes of AI, the implementation of RPA has been powerful than ever [23]. There are use cases where an outcome is not 100% guaranteed to be correct. For example, value of a property, analyzing the risk of a loan default, and predicting inventory. If we want to value a property, we need to consider some key factors such as the age of the house, the location and so on. Each of this needs to be analyzed against each other to forecast the value. Earlier, only human brain could do such complex calculation. Now, AI can help robots to accurately predict the results using its advanced techniques.There are cases where the outcome depends on multiple variables. For example, finding matching resume for job placements. This a hectic job for recruiters. With the help of AI, robots can automatically match candidate's skill sets for relevant job posting. Apart from that, robot alone cannot deal with unstructured data (images, video or text). But when advanced AI is combined with the robot, the robot can learn the pattern of unstructured data too. Also, RPA always provides a single kind of outcome. On the other hand, AI can work on both structured and unstructured data to produce different kind of outcomes and predictions.

To enhance the functionality of both of these technologies, there is a need to combine these two technologies. [24] mentions the integration of RPA, AI and soft computing as Intelligent Automation (IA). The authors furthermore, categorize IPA as a part of IA. In our paper, we will mostly focus on IPA. An overview of IA technology is illustrated in figure 4.

IPA [25] combines RPA and AI with other advanced technologies into one preconfigured software instance that is

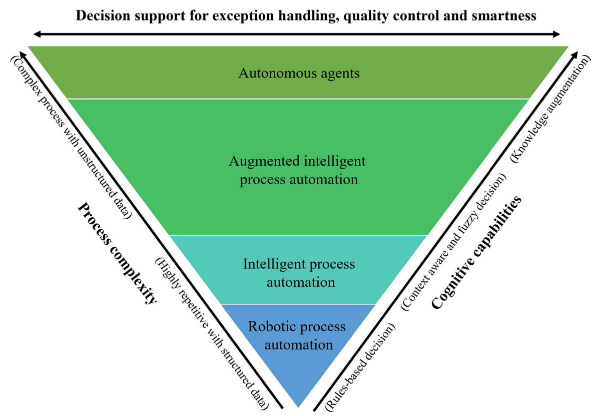

FIGURE 4. An overview of IA [24].

capable of executing processes that require routine tasks with minimal human input [26] as well as cognitive capabilities such as infusing NLP technology [27], [28], [29]. The IPA technology need low level of human intervention in compared to RPA process. However, they need fine tuning to select optimal ML models. IPA has been utilized in both internal (back office) and external (front office) services in industries such as banking [30]. In recent years, several studies have been conducted on the applicability, challenges and potential of IPA. These studies include case examples [31], such as automatic discovery and data transformation, auditing [32], business process management, and productivity optimization [33]. There have been studies on different tools that have made integrating AI in RPA easier. In our next section, we will focus on the tools.

VI. TOOLS THAT ADAPT AI TECHNIQUES IN RPA AUTOMATION

A. UiPath

UiPath is a software company which provides platform to create software bots for business process automation. It has an architecture based on web Orchestrator that is built on .NET. It facilitates the development and execution of RPA functionalities through a block-based interface and various plugins for business process automation. The platform operates with three specific modules; UiPath Studio, UiPath Robot and UiPath Orchestrator. UiPath Studio is used to design, model and execute workflows, while ensuring the management and transfer of packages between robots. The workflows are created by RPA developers. UiPath Orchestrator is used to upload bots in cloud, deploy them and manage the resources. Various configurations such as, saving login credentials of websites or platforms, scheduling the runs, storing multiple bots are managed in Orchestrator. An RPA admin usually takes care of such things. There are two kinds of robots; attended and unattended. The attended robots need human intervention to complete tasks whereas unattended bots can run independently. UiPath offers five types of recorders: basic recording for individual activities, desktop recording for

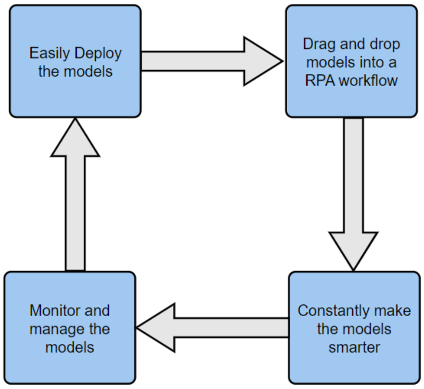

FIGURE 5. Four stages of integrating ML models in AI Center.

capturing multiple actions across different applications, web recording for recording activities in web browsers, and image and Citrix recording for virtual environments, which support image, text, and keyboard automation [34].

According to UiPath documentation [35], UiPath has now connected AI in the tool by introducing AI Center. AI Center allows to coordinate all the stages of AI life cycle, including deploying, utilizing, managing, and enhancing machine learning models as shown in the following image 5.

1) EASILY DEPLOY MODELS

It allows for seamless integration of AI into the automation processes. It has made possible to oversee the models, monitor their development, interact with them, and validate predictions to improve accuracy over time. AI Center simplifies the deployment and scaling of AI in production environments. Users can upload their own models or choose from a variety of pre-built models offered by UiPath, UiPath's partners or the open-source community.It has made deploying easy with just a few clicks. The user-friendly interface allows data scientists and RPA developers to focus more on addressing business challenges and less on development operations and engineering tasks.

2) DRAG AND DROP MODELS INTO AN RPA WORKFLOW

It allows injecting ML models with its simple drag and drop interface. It is easy to choose ML models from dropdown and inject them into the workflows developed in UiPath Studio. As the ML models get trained on data, they recognize unstructured data and their patterns to make predictions. This increases the scope of automation capacity by allowing companies to automate complex business models that has cognitive requirements. Also, as UiPath allows users to choose ML models, the data science team do not need to spend much time on implementing models. This will increase productivity and free up resources.

3) MONITOR AND MANAGE THE MODELS

The platform enables users to monitor machine learning model consumption at the tenant level. It allows for model updates to new versions and provides the ability to revert to previous versions if necessary. AI Center enhances understanding and engagement not only for data scientists and RPA developers but also is a beneficial tool for business users and leaders. By observing models and automation in action within a single platform, leaders and managers gets more visibility which helps them to understand what works for their business and what does not.

4) CONSTANTLY MAKE THE MODELS SMARTER

The power of AI Center increases over time as models get improved with the validation and learning of experienced developers. Developers identify low-confidence predictions made by model and update the model by retraining and changing parameters. This eventually increases the potentials of automation.

B. Kofax

Kofax [36] is a company that automates business processes for companies and organizations. They have Kofax intelligent Automation platform that includes capabilities such as AI, RPA, Cognitive Capture, Process Orchestration, Advanced Analytics and so on. It allows data extraction from web, email, local files and ERP systems. It now incorporates AI techniques and algorithms for document content, context recognition, and information classification in emails, web portals and documents. The tool uses machine learning approaches for supervised learning in OCR document recognition and classification and natural language processing for both supervised and unsupervised learning to analyze content. Supervised learning is one of the versions of machine learning. The algorithm in supervised learning learns from the data about the labels during training phase by making repetitive prediction and correction. On the other hand, the algorithm in the unsupervised learning generates inferences without knowing the labels [37]. Natural language processing is considered as a type of both supervised and unsupervised machine learning which creates a way to analyze texts by computerized means [38].

C. AUTOMATION ANYWHERE

Automation Anywhere [34] is a leading provider of RPA tools. It offers a client-server-based architecture. It has three main components; Bot Creator, Control Room, and Bot Runner. The Bot Creator facilitates the easy design and automation of bots. The Control Room handles the execution and scheduling of bots, manages credentials, addresses security issues, and oversees client permissions and assessments. The Bot Runner is responsible for running bots and recording analytics which are then sent back to the Control Room. Automation Anywhere supports three types of bots which are Task Bots, Meta Bots, and IQ Bots. Task Bots are used for automating rule-based, repetitive tasks, while Meta Bots serve as reusable building blocks for other bots. IQ Bots, on the other hand, have cognitive and intelligent capabilities for processing unstructured data. The platform offers three types of recorders—Screen Recorder, Smart Recorder, and Web Recorder—to automate tasks which mimics user actions. Additional features of Automation Anywhere include BOT INSIGHTS, an analytics engine that visualizes user data to provide business insights. Then there is BOT FARM, which allows companies to purchase RPA tools based on usage rather than capacity or licenses. Lastly it offers BOT STORE, a marketplace where various plug-and-play bots are available.

Automation Anywhere has added a functionality called AI Agent Studio in their system to build AI Agents [39]. AI agents are software programs designed to interact with their operating environment that perform cognitive tasks and make decisions autonomously or semi-autonomously by analyzing data using machine learning algorithms. The features of AI agents are as follows [40]:

Purpose-Driven: AI agents are designed with specific objectives rather than following a set sequence of steps. They utilize all available capabilities and information, including organizational knowledge and environmental perceptions to conduct their assigned tasks.

Autonomy/Partial Autonomy: AI agents can operate based on their on intellectual without the need of any human intervention. They are smart enough to take decisions and act accordingly to target their goals.

Memory: AI agents keep track of their plans, experience and communication to ensure continuity of their work, inform future actions and update in their performance.

Planning: AI agent create sequence of their tasks and work according to the objective. Their planning capabilities have improved with the integration of Large Language Models (LLM).

Perception: AI agents continuously perceive and process new information in real-time. Using sensors and data inputs, they can assess their surroundings and adjust their actions when needed.

Reasoning: AI agents have the ability to make decisions and solve problems. By processing new information and connecting their perceptions of the environment or situation to their foundational knowledge and predefined objectives, AI agents is able to determine the optimal course of action.

Action: AI agents are capable of taking action. They can interact with and influence their environment to meet their assigned goals and objectives by being connected to actuators and execution systems, such as ERP applications.

Reference [40] also describes different types of AI agents. Each AI agent type, whether simple reflex or hierarchical, possesses distinct strengths and characteristics that make them appropriate for different enterprise automation situations. AI agents are categorized based on traits like reactivity or proactivity, the characteristics of their environment, and whether they function individually or within multi-agent systems. For instance, static environments may need agents that can perform responsive tasks, whereas dynamic environments require AI to learn and adapt. The type of AI agents are as listed below [40]:

Simple Reflex Agents: They rely on predefined rules and current data or signals. They are effective for straightforward cognitive tasks that needs quick responses without in-depth reasoning. For instance, they can reset customer passwords when certain keywords appear in a conversation or adjust the temperature in smart homes based on thermostat readings.

Model-Based Reflex Agents: Unlike simple reflex agents, Model-based reflex agents utilize an internal model constructed from data inputs and perceptions to make informed decisions. This capability makes them suitable for more complex tasks that involve predicting outcomes such as recommending driving routes based on maps and real-time location updates.

Goal-Based Agents: Goal-based agents do not just follow rules in straight-forward manner. Rather they, evaluate methods using its reasoning capability for achieving a task. For instance, these agents can assist in scheduling tasks that need to meet specific deadlines or constraints.

Learning Agents: As their name suggests, learning agents constantly adapt and enhance their performance through experiences and collected. This approach makes them ideal for tasks like recommendation engines, which better align with user preferences as they learn from feedback and interactions.

D. BluePrism

BluePrism is another leading company that provides solution for automation using RPA [34]. It uses Java and .NET frameworks and offers drag-and-drop interface for designing RPA solutions. It has four main components; Process diagrams, process studio, object studio, and application modeller. Process diagrams represent business workflows which are created utilizing core programming concepts. Process studio offers a platform to create these diagrams using various drag-and-drop activities. Object studio is used to create Visual Basic objects that enable communication with other applications. Application Modeller creates application models within Object Studio which exposes the UI elements of a target application to the Blue Prism program.

According to the documentation of BluePrism [41] they have introduced Intelligent Automation Platform (IAP) where it combines the power of AI and ML in RPA. The features of IAP are described as follows:

Design Studio: Design Studio allows to build automated processes with a simple drag-and-drop interface so we don't need to write any code. It also allows to create reusable 'objects' that can trigger events within a process. This makes it easy to scale automation across the entire business.

Digital Workforce: A digital workforce consists of autonomous software robots that use AI technologies to mimic human intelligence and learning.

Control Room: The Control Room trains digital workers and assign them specific tasks while providing real-time insights into how these processes are performing.

Blue Prism's IPA solutions deliver value in five different ways [41]. One is creating journeys. It helps assessing, advancing and improving processes. Second one is, accelerating work. This adds benefits by automating tasks using insights for complex works such as processing documents. The third one is, transforming experience which helps to transform business by empowering workforce with new experience. Last one is, offering an enterprise platform and robotic operating model that makes the solution scalable, secure and offers flexible deployment. So, the overall technology that are used to create intelligent automation in BluePrism are: RPA, NLP, AI, Business process management (BPM), ML, process discovery and process mining. A comparison between the highly used RPA tools (UiPath, Automation Anywhere and Blue Prism) is also presented in Table 2.

Apart from the above mentioned tools, there are few more tools where AI and RPA are integrated together to automate processes. Such as, AssistEdge [42], Automagica [43] and WinAutomation [44]. In the next few sections, we will talk about the use cases and applications of IPA solution across various industries.

VII. AI DRIVEN RPA IN FINANCE AND BANKING

The development of financial process intelligence has leveraged advances in technologies such as cloud computing and AI to enhance process automation. RPA is utilized to mimic user interfaces through cloud computing which facilitates extensive automation of tasks like data entry, form filling, and email handling in financial operations. IPA integrates AI algorithms to handle unstructured data, make complex decisions, and optimize processes through learning and feedback. This combination enables financial organizations to automate back-office operations, reduce labor costs, and increase productivity [46]. Banking industry can also be benefited with AI based RPA systems. It helps banks in various ways starting from fraud detection to loan processing. And finally, this can increase bank's revenue, lower operating costs and compliance and increase customer satisfaction.

A. APPLICATIONS AND USE CASES: FINANCE AND BANKING

Kai et al. [47] describe how AI and RPA are combined to enhance the financial office's intelligence and automation capabilities. This architecture utilizes RPA for conducting repetitive tasks accurately while AI provides cognitive abilities for intelligent decision-making. Here, they create a robot that includes dual architecture where RPA acts like "hands" and AI acts like "brain" of the robot.

This design is based on two main components: human-computer interaction and software workflow. The human-computer interaction focuses on how financial staff deal with software to ensure smooth communication and task completion. On the other hand, the software workflow component makes interaction between AI and RPA to execute defined tasks. Their system architecture can be divided into three phases like the following figure 6.

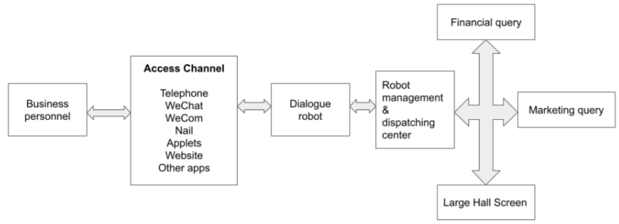

FIGURE 6. The combined architecture of RPA and AI [47].

Data Collection: Here, RPA is used to collect data from different sources such as financial systems, emails and local servers. It captures and records voice commands received by microphone. RPA streamlines this data collection process by conducting repetitive data gathering tasks.

Data Processing: After that AI is used to recognize and transform user's voice into text, which is basically instructions from users. By using feature extraction and other advanced techniques, the robot management and dispatching center turns the texts into meaningful instructions and forwards them to robot actuator for task execution.

Report Generation: Lastly, the robot actuator conducts business actions by following the instructions. In terms of result, it provides financial query, tobacco marketing query, large screen control and etc, and returns the final output to the end user through a user interface.

The architecture incorporates additional technologies like cloud computing and blockchain to improve interaction between RPA and AI. The main goal of this study is to smartly automate routine tasks and improve decision-making through collaboration between RPA and AI.

In another study [48], they discuss about some use cases where RPA and AI can be applied in the field of Banking.

1) USE CASE 1: LOAN PROCESSING

The loan process generally involves the customer completing numerous forms, which the bank then verifies. The bank checks customer's credit history before approving the loan and disbursing the funds. Intelligent automation powered by AI and RPA can play a major role here to automate the end-to-end processes and transform business operations. The figure 7 bellow depicts a recommended way for an automated load processing focusing on the applicability of AI and RPA.

a: LOAN APPLICATION AND DOCUMENT SUBMISSION

In the loan application process, while some banks have digitalized systems for submitting applications, others still rely on paper forms. For these banks, RPA using its OCR (Optical Character Recommendation) technology can automate data extraction and entry to bank's loan system. Since the data entry is a manual and error prone process, here RPA can help improving accuracy and efficiency. also, as loan

TABLE 2. Comparison of RPA Tools: UiPath, Kofax, Automation anywhere and Blue Prism.

Parameters	UiPath	Automation Anywhere	Blue Prism
Scalability	Highly scalable with orchestrator for managing bots and resources and for including attended and unattended bots.	Highly scalable with **BOT FARM** features that allows purchase based on usage.	Offers IAP enterprise platform and robotic operating model for making solution scalable.
User Interface and Deployment Simplicity	Modules like **UiPath Studio** Offers drag and drop interface, **AI center** allows users to monitor ML models consumption and **UiPath Orchestrator** makes bot deployment easy.	Offers a user friendly design interface with **Bot Creator** component. Also includes **Smart Recorder** to follow user action from interface. AI agents enhances deployment collaboratively.	**Design Studio** from IAP platform provides drag and drop interface to create bots. IAP also offers flexible deployment.
Pricing	Aggressive and lucrative entry level pricing [46]	Higher cost of deployment specially for smaller organization [46].	High cost [46].
Capabilities for Integration	Supports ML model integration through AI Center, provides option to choose prebuilt ML models.	The integration of machine learning models like LLM helps AI agents to take cognitive decisions.	IAP platform integrates NLP, AI and ML models with RPA to solve complex business problems

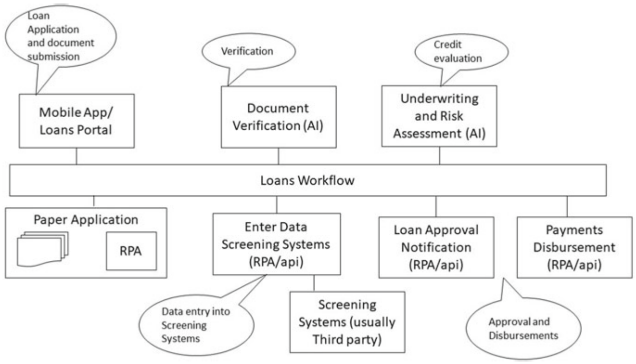

FIGURE 7. AI and RPA integration in loan processing [48].

documents usually follow a standard format, using RPA is often sufficient without applying advanced AI. However, this approach should be assessed for feasibility.

b: VALIDATION AND SCREENING

The next step is to validate the documents submitted in banking system. To validate the data, system needs to extract correct data and then verify them against correct source. For example, the driving license should be verified against trusted motor vehicle database. For this, there is a need to apply artificial intelligence to do document processing and data extractions. This requires techniques like segmentation, text processing, text retrieval, paragraph retrieval and key value pair extractions. This will provide them text version of documents such as PDF or images. After that, implementation of AI will do text analysis to extract the correct meaning of the data specially from paragraph like texts. This approach is referred to as Intelligent Automation (IA) [49]. Research indicates that text analysis from documents like PDFs requires both OCR and NLP. Most OCR methods use an algorithm that is trained on a known dataset to accurately label or classify the character set in the dataset. According to [50], some of the popular algorithms used in OCR techniques are K Nearest Neighbor (KNN), Naïve Bayes Classifier, Neural Network and Support Vector Machine (SVM). KNN classifies objects with similar

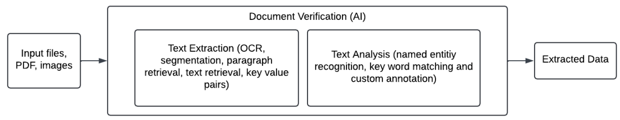

FIGURE 8. AI component for document verification [48].

features within a specified proximity. Naïve Bayes classifier is a probabilistic classification that uses Bayes theorem of probability to identify the class of a new or unknown data. Neural Network focuses on underlying relationships of characters and words to extract data which is considered as a strong ability in [51]. Lastly, SVM has been found to be a better performer than any other classification algorithm in the context of OCR as it does not work based on assumptions as Naïve Bayes classifier does. The figure 8 illustrates the system component where AI is applied.

After data extraction, the information from documents is verified against trusted sources via system integration that may run in real-time or batch mode. Customer profile and transaction screening involve specialized systems that compile data from multiple sources. This requires bank agents to input data manually for analysis which is a labor-intensive process. This is where RPA can again help and automate data entry, especially when third-party systems may not always support API calling or other methods. Additionally due to dealing with sensitive data, these systems are typically hosted on-premises within the client's network. Therefore, RPA offers a non-invasive and cost-effective way to automate the repetitive data entry process. This helps from preventing manual error and speeds up the process as well.

c: UNDERWRITING AND RISK ASSESSMENT

The subprocess of evaluating a customer's creditworthiness is vital in the loan process which is shown in the following figure 9.

It involves analyzing data from various sources to assess lending risks, detect potential fraud, and evaluate the customer's financial stability. RPA bots automates data collection from multiple sources or even crawl portals to fetch data, while AI uses algorithms to predict risk assessment scores.

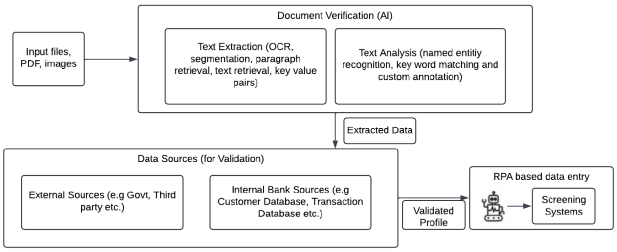

FIGURE 9. Data extraction and validation solution [48].

This combination of RPA and AI enhances the efficiency and accuracy of credit evaluations while assisting bankers in making informed decisions. Common AI algorithms used include K-Nearest Neighbors, Logistic Regression, Decision Trees, and Neural Networks, with service providers offering simplified solutions for risk assessment modeling.

d: LOAN APPROVAL AND DISBURSEMENT

Next step is, loan approval and payment disbursement. This subprocesses can be automated using workflows, API integration, or RPA, depending on the requirements. While RPA offers quick, temporary solutions, API integration is considered as a long-term, approach. The choice between RPA and API should be based on factors such as speed, cost, and benefit. Applying AI and RPA in the loan process can transform operations which significantly improves KPIs through straight-through processing and better customer experiences. These technologies have a direct and positive impact on the efficiency and effectiveness of loan services.

2) USE CASE 2: FRAUD DETECTION

The fraud detection operations process involves data gathering and analysis to find patterns, anomalies and outliers that may suggest fraud. It includes alert responses, transaction investigations and potentially taking actions such as reversing transactions or initiating legal proceedings. RPA and AI can significantly enhance efficiency and KPIs in fraud detection and investigation. RPA bots streamline data preparation by navigating systems and organizing data, while AI and machine learning models identify patterns and relationships to support investigations. Both supervised and unsupervised machine learning algorithms are used to detect hidden patterns and relationships which improves the effectiveness of fraud detection and decision-making. Figure 10 shows four phases of fraud detection operation where RPA and AI can be implemented together in three phases.

B. CHALLENGES: FINANCE AND BANKING

Although AI-powered robotic process automation (RPA) has great potential to revolutionize a number of banking and financial services, putting it into practice presents a number of limitations. These limitations are a result of operational, ethical, legal, and technological aspects. The main issues raised by the use cases that were covered are listed below, along with some more information from pertinent research papers.

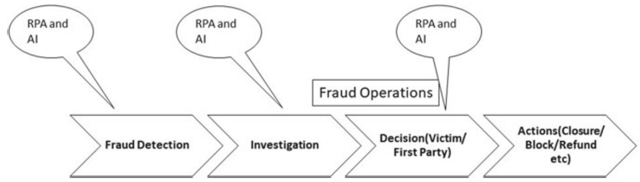

FIGURE 10. RPA and AI solutions for banking fraud operations [48].

1) DATA QUALITY AND INTEGRATION ISSUES

Both studies highlighted the critical role of data collection, processing and validation in the financial and banking areas. However financial institutions often rely on legacy systems that may not be compatible with modern AI and RPA technologies that leading to data inconsistencies and integration difficulties. And so ensuring high data quality and seamless integration across multiple systems is a critical challenge when implementing AI and RPA in banking. Inaccurate or incomplete data entries can lead to incorrect AI predictions, which can be particularly problematic in processes like loan approval or risk assessment [47]. Integrating various systems and ensuring data flows seamlessly between AI and RPA components is also challenging due to legacy systems and fragmented IT environments.

2) REGULATORY COMPLIANCE AND RISK MANAGEMENT

When using AI and RPA to automate tasks like fraud detection and loan processing one must take into account the dynamic and complicated regulatory environment. A major problem in the banking business is that it adheres to tough regulations such as GDPR, AML (Anti-Money Laundering) and KYC (Know Your Customer) etc. For regulatory compliance it is imperative that AI predictions are auditable and explicable particularly when it comes to loan processing and fraud detection [48]. Furthermore, updating AI models and RPA workflows on a regular basis is necessary to maintain compliance due to the changing nature of regulatory environments. When it comes to the application of RPA in banking, Patri [52] explores the difficulties associated with regulatory compliance. Through the implementation of strong governance frameworks and transparent and explainable AI decisions, the paper offers insights into how banks may effectively manage these obstacles.

3) SECURITY AND PRIVACY CONCERNS

Security and privacy are major concerns since the banking industry uses AI and RPA to process massive amounts of sensitive personal and financial data. Financial institutions need to make sure that data protection laws are followed while safeguarding this information from cyberbullies. AI models used in fraud detection and other critical banking operations can become targets for adversarial attacks, where malicious actors attempt to deceive the AI system. Moreover the integration of AI and RPA increases the attack surface and potentially exposing banks to higher risks of data breaches [48]. The study by Iyamu and Mlambo [53] provides an analysis of security and privacy challenges in the context of RPA implementation in the banking sector. The authors emphasize the importance of addressing these concerns through robust security measures and privacy frameworks to protect sensitive data. The study by Choubey and Sharma [54] examines the impact of RPA on sustainable banking in India, highlighting that despite potential risks related to security and privacy, the adoption of RPA in banking is expected to grow significantly. The research emphasizes the future integration of robots with human workers, predicting that RPA will enhance efficiency and support sustainable economic models in the banking sector.

4) SCALABILITY AND SYSTEM INTEROPERABILITY

The challenge is in ensuring that AI and RPA projects by banks and financial institutions can handle growing workloads and seamlessly interface with a diverse range of other tools and systems. When bottlenecks arise from interoperability problems, automated operations become less efficient overall Kai et al., [47]. In the context of smart RPA application in financial operations, Gotthardt et al. [55] describes the difficulties with scalability and system compatibility. To guarantee that AI and RPA systems can scale efficiently and interface with other systems without any problems, the study emphasizes the necessity of strong frameworks.

5) ETHICAL AND BIAS CONCERNS

AI models have the potential to unintentionally add biases and provide unfair results, especially when applied in procedures like fraud detection and loan processing. For instance, if the training data has ingrained biases, AI-driven loan approval systems may prejudice against particular demographic groups. Since AI models frequently learn from potentially biased historical data, it is imperative yet difficult to ensure that these algorithms are transparent, equitable, and devoid of prejudice [48]. Addressing these ethical concerns is essential to maintain trust and avoid reputational damage. The ethical and bias-related issues surrounding the use of AI and RPA in the banking industry are addressed in the paper by Jaiwani and Gopalkrishnan [56]. The authors mention how rigorous examination of AI models is necessary in high-stakes domains like loan approvals and fraud detection to guarantee that they do not reinforce preexisting biases.

While the challenges discussed above are significant, they can be addressed through targeted strategies and innovations. Banks may create middleware solutions and invest in sophisticated data cleaning tools to address problems with data integration and quality. This will help close the gap between legacy systems and contemporary AI-RPA technology. To address security and privacy concerns, financial institutions must implement advanced encryption, regular security audits, and adversarial defense mechanisms to safeguard sensitive data. Finally, ethical concerns around bias in AI models require ongoing monitoring, regular re-training on unbiased datasets, and active human oversight to ensure fairness and equity in processes of the banking industry. By adopting these measures, organizations can mitigate the challenges and fully leverage the potential of AI-powered RPA in financial services.

VIII. AI DRIVEN RPA IN AUDIT

Auditors usually deal with heavy workloads as they have to meet strict deadlines in most cases. A survey of over 700 auditors examined the relationship between audit workloads, perceived audit quality and job satisfaction. It shows that auditors need to work an average of five hours per week beyond their schedule which decreases the quality of their work [57]. Strict deadlines and the shortage in number of resources are considered to be the primary factors for the excessive workloads. Furthermore, the survey found that auditors' job satisfaction decreases significantly when workloads surpass the level that negatively impacts audit quality. These findings align with the PCAOB's concerns that heavy workloads threaten audit quality and suggest that the main drivers of excessive workloads could be the root cause of workload-related audit deficiencies. If the audit is conducted by external agencies, there is a possibility that there will be corruption and loopholes [58]. To address these challenges, public accounting firms are exploring the potentials of RPA [59], [60], [61], [62] and AI [63], [64], [65] to enhance the capability of their audit software. The term automation is not new to managers of auditing firms as it always requires multiple repetitive tasks such as reconciliations, internal testing and detail testing. Earlier audit firms were dependent on scripts written in Python or R language. For that they needed to hire developers or programmers which was a major investment of money. That's why audit firms are not eager to implement automation through RPA [58] that requires low code or no code. However, there have not many researches conducted on AI powered RPA audit processes. We will talk about some of the applications and use cases in our next section.

A. APPLICATIONS AND USE CASES: AUDIT

Reference [66] provides a framework for implementing IPA in audit. They divide their framework in three sections; Analyzing the audit workflow, automating individual audit tasks and forming the IPA structure. Analyzing the audit workflow involves determining the primary, secondary and lower-level workflows. They mention that, a detailed understanding

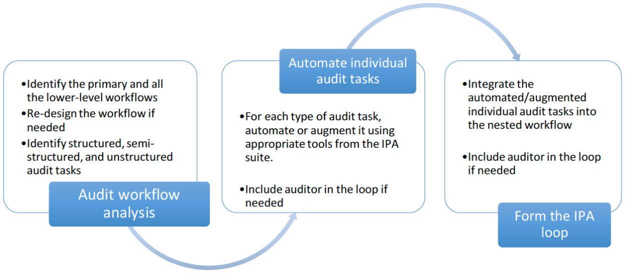

FIGURE 11. Framework of IPA implementation in audit [66].

of the workflows is necessary to evaluate if the current workflows need any modifications.

Once the analysis is done, next step is to automate individual audit tasks. The tasks can be categorized into structured, semi-structured and unstructured task. Tools from RPA are utilized for automating structured tasks such as data extraction and file organization. Semi structured tasks can be conducted by AI technologies such as natural language processing and computer vision. Unstructured data are supported by cognitive tools as they need expert's attention. This is to ensure final output is accurate.

The final step is to integrate both the automated and augmented tasks in audit workflow to form a loop called IPA. The figure 11 below illustrates the IPA loop.

After automating or augmenting individual audit tasks, these tasks are reintegrated into the layered workflow until the primary workflow loop is completed. For instance, during the audit planning phase, previously automated tasks might include file organization via RPA, file processing through NLP, and client risk assessment supported by a cognitive assistant. The next step involves organizing these tasks back into the workflow. Files organized by RPA are sent to NLP for essential information extraction, and the results are then passed to the cognitive assistant, which helps auditor understand client's risk level. Once the auditor assesses the client's risk with cognitive tool assistance, the information is forwarded to the internal control testing workflow. This process of completing lower-level tasks and passing results to higher levels continues until the audit engagement concludes which completes the primary workflow. If necessary, workflows can be re-triggered, updating all subsequent workflows and forming a continuous loop.

According to another study [63], EY, one of the Big 4 audit firms, develops analytics tools for the purpose of analyzing huge amount of data in a shorter period of time. EY also employs RPA technologies to automate most time-consuming, repetitive, traditional and rule-based tasks and leave the complex tasks for AI.

Reference [67] mentioned that the HR group of Coca-Cola is running HR Automation to run audits in SAP which is enabled by Blue Prism's intelligent automation. So far, more than 50 processes are automated by this beverage giant across multiple SAP systems which helps them deliver services 24 hours a day with no additional staff required.

B. CHALLENGES: AUDIT

The integration of AI and RPA into audit procedures raises a number of important challenges that differ from those faced by the banking and financial industries. Although there are many advantages to IPA in auditing, there are also many drawbacks, including the intricacy of audit activities, the requirement for accuracy, and the integration of many technologies. Here, we focus on the particular difficulties caused by various implementations, as supported by corresponding studies.

Processing unstructured data is an important challenge for automating audit tasks. Artificial intelligence (AI) approaches such as natural language processing (NLP) and cognitive tools are necessary to handle unstructured data, whereas RPA solutions can handle structured data with ease. These technologies must accurately interpret and analyze unstructured information such as client communications or complex financial statements which is often nuanced and context-dependent. Ensuring that AI systems can reliably handle these tasks without human oversight is a significant challenge. The study by Zhang [66] emphasizes the difficulty of automating semi-structured and unstructured audit tasks. The paper discusses the need for sophisticated AI tools to support these tasks and highlights the risks of errors if these tools are not properly implemented.

Moreover, the integration of these automated tasks back into the audit workflow poses another layer of complexity. Each automated or augmented task must seamlessly interact with others within the layered workflow. Any disruptions or failures in one part of the loop can have cascading effects, leading to delays or errors in the audit process. For example, if NLP tools misinterpret critical data during the file processing phase, this can lead to incorrect information being passed to cognitive assistants, potentially resulting in flawed risk assessments. The integration challenge is exacerbated by the need for these technologies to work harmoniously in a dynamic and often unpredictable audit environment.

Additionally, there is a challenge in maintaining the continuity and accuracy of the IPA loop over time. As workflows evolve and new audit requirements emerge, the IPA framework must be adaptable enough to accommodate these changes without significant reconfiguration. This requires ongoing updates and fine-tuning of the automated tools, which can be resource-intensive. Moreover, ensuring that the entire workflow remains synchronized is a complex task, as each update or modification to the workflow can affect multiple layers of the IPA structure.

An additional difficulty lies in the possibility of auditors experiencing cognitive overload when utilizing these sophisticated technology. Although the goal of cognitive tools is to help auditors make better decisions, they also present auditors with additional interfaces and data streams to handle. The possibility exists that auditors could get overpowered by these technologies' complexity, especially if they lack the necessary training to utilize them properly. This increases the possibility of errors or a dependence on technology without enough critical monitoring, especially in the setting of an audit where judgment and accuracy are crucial.

Finally, it is impossible to overlook the difficulty of guaranteeing the IPA process's auditability and transparency. The necessity to make sure automated processes are visible and auditable independently is developing as audits depend more and more on them. This means that all choices made by AI tools, as well as the procedures they adhere to, ought to be completely transparent and intelligible to human auditors. It is challenging to maintain this degree of openness, particularly as AI models grow increasingly intricate and difficult to understand. There may be questions regarding the dependability of the IPA-integrated audit process if there are unclear audit trails, as it may be difficult to confirm the audit's accuracy.

Gotthardt et al. [55] highlight several critical challenges in implementing Smart Robotic Process Automation (RPA) in auditing, including data quality and integration issues, cybersecurity risks, and the need for transparency and governance. The paper also emphasizes the complexity of implementation and the resistance to change within organizations, pointing out that successful adoption requires careful planning, ongoing maintenance, and a focus on training to bridge skill gaps.

To address these challenges holistically, organizations should adopt a proactive approach that combines technological innovation with robust governance and training frameworks. Collaborative efforts between AI developers, auditors, and management can ensure that automation tools are both effective and aligned with audit requirements. Additionally, fostering a culture of adaptability and continuous learning within audit teams will help mitigate resistance to change and ensure long-term success. Together with continued investments in modular automation systems and explainable AI, these strategies can help reduce the gap between the present constraints and the revolutionary potential of AI-powered RPA in auditing.

IX. AI DRIVEN RPA IN MEDICAL AND HEALTH SERVICES

Technologies applied to medical administrative services are changing over the years and it has now impact on how diseases are treated. Doctors are also depending on automation process to diagnose problems and even treat patients. Besides, automation can help in managing people, supplies and taking care of financial documents in medicals, hospitals and health care clinics. RPA has gained its popularity in healthcare for automating repetitive tasks, optimizing processes and minimizing human errors. Leveraging RPA has also increased productivity and helped in resources management which eventually results in better customer experience and job satisfaction [68], [69]. On the other hand, AI and ML have proven its diagnostic capabilities by analyzing large datasets, identifying patterns and generating insights. While RPA and AI technologies offer unique benefits when used individually, their integration shows a paradigm shifts in healthcare diagnostics.

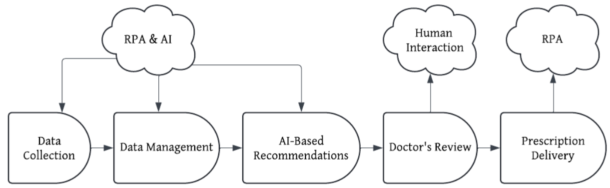

FIGURE 12. Telemedicine workflow with RPA and AI.

A. APPLICATIONS AND USE CASES: MEDICAL AND HEALTH SERVICES

According to [69], the design of Randomized Clinical Trials (RCT) involves collecting huge amount of data to utilize them accurately. As data needs to be entered manually, RPA can help managing the data in the main file by following a fixed data structure. After that, AI enabled system can do data verification to check if there is any missing data. With trained bots, the missing data can be filled as well.

Reference [70] mentions several use cases on AI enabled RPA system which are as follows:

1) CALCULATING THE PRECISE USAGE OF MEDICINES

This study shows that RPA can be used to collect and manage data related to drugs. They give an example of a system that can be installed to monitor the use of medicines or drugs. The system can be used to predict the number of medicines required based on the saved record of previously admitted patients and their common health issues. Then using RPA, the system can automatically generate emails to authorities so that they can place order of medicines before they get out of stock. Furthermore, the AI-enabled hospitals can communicate between each other to estimate the number of drugs and predict the rise in the price of the same drugs. Through communication, hospitals can also forecast medical emergencies, alert doctors, get supply of medical facilities, prepare infrastructure, plan enough resource in terms of shifts.

2) TELEMEDICINE

There are apps that can turn flashlights into an electrocardiogram (ECG) device which helps doctors to diagnose various heart-related conditions. Reference [70] shows, how apps like these can be used to collect data through RPA and create a database system with that data. While, RPA can be used to manage the data, AI system can recommend medications based on patient's health condition [71]. In the final stage, doctors can review, modify and approve the medications for patients. Once approved and payment is completed, the prescriptions can be sent to nearby pharmacies where patient is located. The entire telemedicine workflow, including data collection, management, AI-based recommendations, and the doctor's final review, is visually represented in Figure 12.

3) CELL AND TISSUE ENGINEERING

Cell and tissue engineering are at the cutting edge of medical research. Cell growth is categorized into autologous therapy, which is personalized using the patient's own cells and does not require mass production, and allogeneic therapy, which aims to scale production for widespread use. However, due to phenotypic drift, cell engineering is generally feasible only on a small scale. To address these challenges, engineers are turning to intelligent automated systems, such as AI-enabled RPA [72], [73], [74].

4) DATA CURATION

While data availability is not an issue today, data quality remains a concern. Medical images, such as CT and MRI scans, can be challenging to interpret, which may lead to errors in AI classification tasks. Using properly curated data with benchmark evaluations can enhance model accuracy and robustness. RPA can facilitate data collection and curation, including steps like obtaining ethical approval, accessing databases, querying, re-identifying, transferring data, performing quality control and preprocessing tasks like resizing and labeling. According to a framework proposed by [75], RPA can also be helpful in eliminate duplicates while data preprocessing.

5) RADIOLOGY

An average radiologist on an 8-hour shift usually interprets an image every 4 seconds which creates significant pressure on the individual, especially with multiple patients waiting [76]. This workload can have negative impact on decision-making which may lead to provide wrong treatment to patients [77]. In such situations, RPA and AI can be highly beneficial. While RPA can be used to do repetitive tasks such as to sort and collect image data, an AI system would be used as a supervised learning model, trained with both input and output data. Once trained, the model can classify anomalies in images automatically which will eventually reduce workload for radiologists.

6) SELECTING ALGORITHM BASED ON TASKS

Medical imaging includes a wide range of specialties, including ophthalmology, pathology, cardiology, and radiation oncology, each with unique data distributions. Algorithms that work for one specialty may not be suitable for another. It also depends on the type of tasks. RPA can assist in identifying the appropriate AI tools and algorithms to apply based on the specific task and data. Once these technicalities are established, the data can be transferred into the training pipeline.

Another paper [21] focuses on how RPA with the help of AI emerged as a transformative tool in the healthcare industry during the COVID-19 pandemic. Few of the cases are listed below:

7) SOCIAL DISTANCING DURING COVID-19

By utilizing software robots or AI, RPA significantly reduced the need for interpersonal interactions. It automated business processes by upgrading applications to interpret, interact, and respond to other systems and handling repetitive tasks such as data entry, file transfers, document filing, and information access. This automation helped healthcare organizations minimize tedious tasks for their employees, leading to increased productivity and social distance during COVID-19. Systems like these also helped saving cost during crisis.

8) AUTOMATION IN HEALTH INSURANCE DURING COVID-19

Hospitals used blue Prism to implement RPA bot in their machine. These bots in health insurance can skip heavy coding and work on desktop software such as Excel to create a standardized process. By taking care of these tedious jobs, it allows machines to do higher order tasks such as using natural language processing to improve documentation.

9) IP MANAGEMENT IN HEALTHCARE DURING COVID-19

During COVID-19 in healthcare, RPA with AI was employed in Intellectual Property (IP) Management to protect innovations, automate workflows, and streamline business operations. This integration is beneficial for IP Audit and Data Mining as it safeguards procedures, and identifies potential IP assets while minimizing costs and effectively managing intellectual property.

B. CHALLENGES: MEDICAL AND HEALTH SERVICES

The integration of AI-powered Robotic Process Automation in the medical and health services sector presents several significant challenges, particularly concerning the implementation and operationalization of these advanced systems.

Data collecting and processing by AI powered RPA system is one of the major challenges when it comes to ensuring its accuracy and completeness. In the context of Randomized Clinical Trials (RCTs), for instance while RPA can automate data entry and management the quality of the data entered is critical. AI systems that perform data verification rely heavily on the initial data's accuracy. Errors in data collection, whether due to incomplete or incorrect information, can lead to flawed analyses and, consequently, incorrect clinical trial outcomes. Moreover, filling missing data with trained bots, although innovative, introduces risks of compounding errors if the imputation models are not sufficiently accurate or representative.

Cell and tissue engineering, especially for large-scale allogeneic therapies faces significant hurdles due to the complexity and variability of biological data. The phenotypic drift and the need for precise control over the environment for cell growth pose unique challenges for AI and RPA. Scaling up these processes while maintaining quality and consistency is difficult and current AI-powered RPA systems may not yet be fully equipped to handle these complexities at a larger scale without extensive human oversight.

Telemedicine applications powered by AI and RPA introduce challenges related to patient data privacy, informed consent and the reliability of AI recommendations. The prescription process can be automated by these systems which might increase efficiency, however there are concerns regarding the transparency and explainability of decisions made by artificial intelligence. For example, patients and doctors may have limited insight into how an AI system reaches its conclusions. It can also raise ethical issues about the system's accountability, especially if an AI's recommendation leads to adverse patient outcomes. Additionally, regulatory frameworks may not be fully adapted to govern the use of such technologies which complicates the widespread adoption of AI-powered RPA in telemedicine.

While IPA systems can significantly reduce the workload of radiologists by automating image classification and data management tasks, there are challenges related to the system's reliability and the potential for errors. The high-stress environment in radiology, combined with the critical nature of accurate image interpretation means that even minor errors in AI-driven image analysis can have severe consequences. Ensuring that AI systems are sufficiently trained and validated to handle the diverse range of imaging data encountered in practice remains a substantial challenge.

The diversity of tasks in medical imaging, such as varying specialties and data types, necessitates highly customized AI algorithms. RPA can assist in selecting these algorithms but the challenge lies in ensuring that the chosen algorithms are appropriate for the specific context. The heterogeneity of medical data means that a one-size-fits-all approach is not feasible and substantial effort is required to match the right AI tools to the right tasks. This requires ongoing monitoring and adjustment as well as deep domain knowledge to guide the selection process.

Kamala Venigandla's paper [75] identifies several key challenges in integrating RPA with AI and ML for improving diagnostic accuracy in healthcare sector. Interoperability issues, concerned about data security and privacy and the necessity of rigorous adherence to regulatory compliance, such as the Health Insurance Portability and Accountability Act (HIPAA) in the US are some of these barriers. Healthcare companies also need to spend heavily in infrastructure and guarantee personnel preparedness by providing sufficient training and assistance. The paper emphasizes the importance of ethical data usage and careful planning during the implementation of these integrated systems.

Saurabh A. Pahune' [78] highlights several critical challenges in deploying AI-powered healthcare systems in rural areas. Among these the integration of AI into existing clinical workflows poses significant difficulties, particularly if the technology demands substantial changes to established processes. Physicians and patients who may be beware of AI technology or concerned about how it may affect clinical decision-making have also demonstrated substantial resistance. In order to enable the effective adoption of AI systems, the paper [78] highlights how crucial it is to make sure that these systems are easy to use and smoothly integrate into current processes. Moreover gaining the trust and acceptance of both healthcare providers and patients is crucial as resistance could impede the effective implementation of AI in rural healthcare settings.

Ensuring data accuracy in RCTs and telemedicine systems necessitates robust validation frameworks, with AI models trained on high-quality, diverse datasets. For cell and tissue engineering, hybrid models combining AI automation with expert human oversight can help manage biological variability and ensure quality control at scale. To mitigate privacy and ethical concerns in telemedicine, integrating explainable AI (XAI) and transparent decision-making processes into RPA systems will enhance trust and accountability. In radiology and medical imaging, domain-specific AI algorithms that undergo rigorous validation and are continuously updated with diverse imaging data can help improve reliability. It is also necessary to invest in user-friendly interfaces and thorough training programs for patients and healthcare personnel in order to overcome opposition to AI in rural healthcare settings. Encouraging broad adoption will require establishing trust by open and honest communication about the advantages and drawbacks of AI-powered solutions.

X. AI DRIVEN RPA IN RECRUITING INDUSTRY

Another excellent application for deploying an Intelligent Process Automation or AI enabled RPA system in large enterprises is in recruitment industry [49]. IPA can streamline the recruitment process by helping recruiters collect resumes from various online portals, analyze specific skill sets, assess candidate value, and filter out spam and unwanted applications. This technology allows recruiting team to identify suitable candidates more efficiently and cost-effectively. IPA not only discards non suitable applications but also aids in sorting relevant resumes and ensure access to applications that closely match job requirements. It supports HR personnel throughout the entire recruitment process, from screening and evaluation to final integration and management. Recruitment industries get benefited not only in the hiring process but also in financial functions. According to Robert Half, the world's first and largest specialized talent solutions firm, many companies, including theirs, are now adopting IPA to streamline and enhance complex tasks, such as tax and compliance reporting and financial statement reconciliation [79].

A. APPLICATIONS AND USE CASES: RECRUITING

In this section we will talk about two use cases from two different studies.

1) USE CASE 1

Reference [80] proposes a system including RPA and AI that will help HR recruiters to rank resumes based on job descriptions. At first, the job requirements are sent to the bot called PrimeBot via emails. The robot then downloads the email to a specific folder. The description can be C++/SQL which will act as a keyword for the robot. The robot then scans various resumes for these keywords and if a keyword is found in a resume, the resume is ranked based on the percentage of keyword matches. The robot parses resumes in any format

(PDF, DOC, TXT) and ranks them accordingly. The output is generated in a CSV file. After that, the resumes are moved from one folder to a final folder based on the percentage criteria. The final folder including the resumes in CSV format is then emailed to the HR recruiter.

For ranking, they propose to use the SVM (Support Vector Machine) classifier. They describe the logic of how SVM works. Given two items, item1 and item2, the SVM classifier determines their order. If item1 is meant to be ranked before item2, the input to the classifier is (item1, item2) and the output is 1. This signifies the correct order. Conversely, if the input is (item2, item1), the output is -1. This indicates that the order is incorrect.

The ranking process for a set of three items, (item1, item2, item3), using the SVM classifier is illustrated by assigning scores based on pairwise comparisons:

$$(\text{item1}, \text{item2}) = 1$$
$$(\text{item1}, \text{item3}) = 1$$
$$\text{Score of item1} = 1 + 1 = 2$$

$$(\text{item2}, \text{item1}) = -1$$
$$(\text{item2}, \text{item3}) = 1$$
$$\text{Score of item2} = -1 + 1 = 0$$

$$(\text{item3}, \text{item1}) = -1$$
$$(\text{item3}, \text{item2}) = -1$$
$$\text{Score of item3} = -1 - 1 = -2$$

Based on these scores, the ranking is: item1, item2, and item3.

This work not only demonstrates that SVM-Rank is particularly effective for ordering items represented as feature vectors but also provides a solution that utilizes both the power of RPA and AI. The whole process is illustrated in the following image 13.

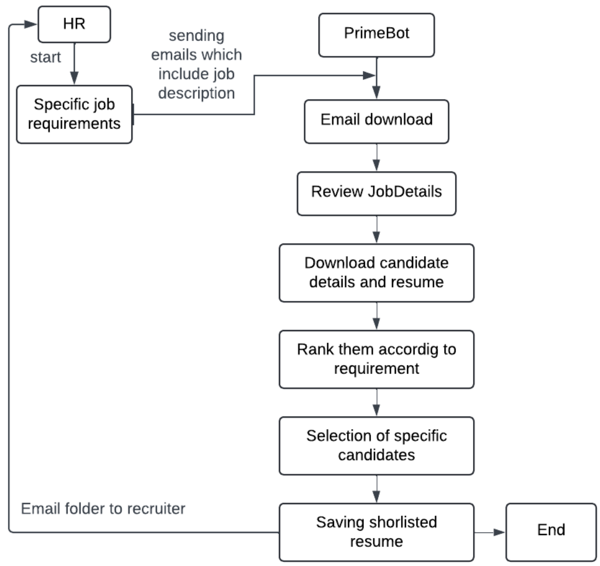

FIGURE 13. **AI and RPA-powered resume screening system [80].**

2) USE CASE 2

Reference [81] provides a solution including artificial intelligence and robotic process automation to release some of the duties from recruiters. The whole solution is illustrated in two in 14 and 15.

Phase 1: The process starts with HR people deciding on the necessary job positions and required skill for the company. After they create the description, the system is able to make a list of technical skill and soft skill needed for the role from the description provided. An HR can modify the list as well. The proficiency of the skill is determined by rating on a scale of 1 to 5 stars. The system also allows job offers to be marked as inactive at any point which will result in removing the job offers from the system

Once job offers are posted on the company's internal portal, it is expected to see several CVs and cover letters. The system will then traverse through candidate's CV search for key words to pull information such as their name, phone number, address and technical skills. An account will be created automatically in the portal with the information. At this point, the system should be able to determine whether the candidate is suitable for the position or not. If the candidate is not a good for the given position but possibly suited for a different position listed in their portal, they will be notified by email and encouraged to apply for the position. If the candidate is suitable for that position, an interview will be arranged virtually by the system. There will be options to choose time through the system that meets with HR's availability. The email will also suggest a set of times for the candidate to choose from.

Although, this paper doesn't mention the technical implementation in details, according to our findings, we have come to this analysis that this solution can use RPA to enter job description in the system, create profile for candidates and send out emails automatically to the candidates. On the other hand, AI models such as LLMs can help extracting candidates relevant information and qualifications even if the CV doesn't follow a single pattern. LLMs can also verify if the candidate is suitable by analyzing the relevance between qualification of the candidate and the job requirements [82]. Decision tree can help categorize candidates (suitable, not suitable, suitable for other positions) based on their specific skills and experience.

Phase 2: Once the candidates are selected from the first phase, they will be asked to participate in the interview online. Their facial expressions can be assessed by using advanced software during the interview. Recruiters and interviewers will take tests in multiple stages to evaluate the candidates. At the end of the recruitment process candidate will discuss their salary expectations and benefits. System will then check if the expectations are reasonable based on the job

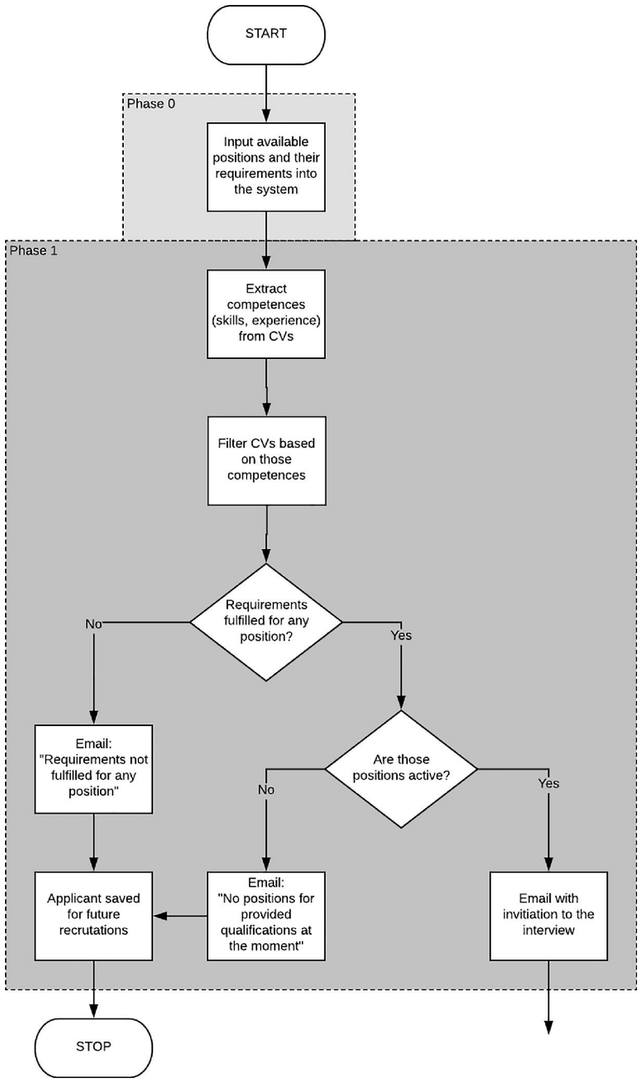

FIGURE 14. Flowchart of Use Case 2 - Phase 1 [81].

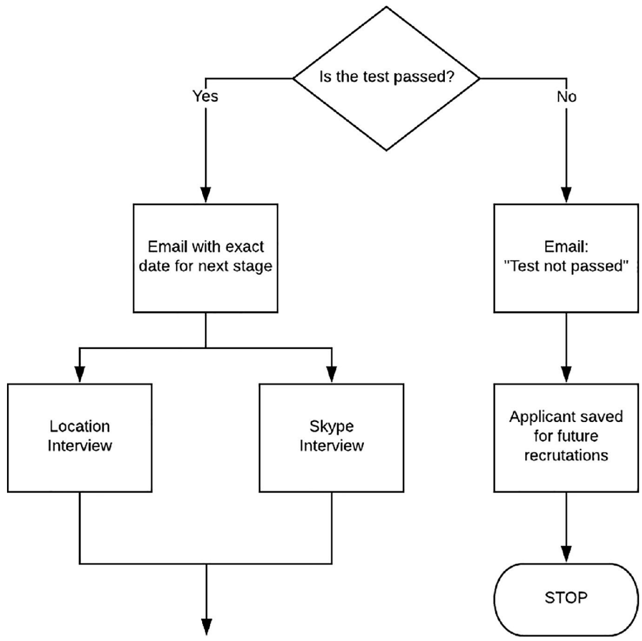

FIGURE 15. Flowchart of use Case 2 - Phase 2 [81].

descriptions and current market analysis. All results including camera reports collected from software will be saved in the database and can be evaluated again later if any positions open up. Here, RPA can again help to insert data into database and scheduling video interview with description on how to use the video platform [83]. Whereas, AI can help to do market analysis.

B. CHALLENGES: RECRUITING

The implementation of AI-powered Robotic Process Automation for resume screening in recruitment processes, as described in the use case involving PrimeBot, introduces several significant challenges as well. One of the primary challenges is the risk of bias in the AI models used for ranking resumes. The SVM classifier, while effective in ordering resumes based on keyword matching, may inadvertently reinforce existing biases present in the training data. Based on the selection of keywords or the historical data used to train the model certain demographic groups might be overrepresented or underrepresented. To ensure that the automated system does not unfairly disadvantage certain candidates, bias mitigation is essential. Studies have shown that AI-based recruitment tools can perpetuate biases if not carefully managed [84].

The process involved in collecting, storing, and processing candidate data raises concerns about data privacy and security. Ensuring compliance with data protection standards like GDPR is important for RPA and AI systems since resumes often contain sensitive personal information. The public release of SVM classifiers could unintentionally expose private details of candidates if the support vectors used in the classification are not properly anonymized.

Another challenge lies in the trust and acceptance of AI-driven recommendations by human recruiters. Despite the efficiency gains, there is often skepticism among HR professionals about relying solely on algorithmic decisions for candidate selection. This skepticism can lead to either over-reliance on the AI system (automation bias) or a preference for human judgment, even when the algorithm is more accurate (algorithm aversion). Research has shown that recruiters may distrust AI systems for making subjective decisions, which can impact the successful adoption of these technologies.

Beyond these technical and privacy concerns, Diwakar Chaudhary et al. [85] emphasize the importance of addressing broader organizational and cultural challenges in adopting AI-powered RPA in HR. This includes tackling skepticism and concerns within the organization, ensuring clear and consistent communication throughout the AI implementation process, and fostering collaboration between humans and machines. Additionally, they stress the need for equipping employees with essential technical skills through comprehensive training programs which encompass computer science, statistics and AI literacy. Creating a culture that values ongoing education and mental flexibility is essential for adapting to how AI technology is changing and how it will affect human resources practices. Leadership plays a pivotal role in maintaining a work environment that encourages innovation, openness and the integration of AI tools while preserving the human touch in recruitment processes.

Seamlessly integrating AI and RPA into existing HR workflows presents another challenge. The HR department must make substantial modifications to its operations in order to make the transition from traditional resume screening to an automated AI-driven process. These improvements might refer to retraining employees, modifying hiring procedures, and ensuring the AI system aligns with the business's current standards and values. The challenge is particularly acute in ensuring that the AI tools complement rather than disrupt the human aspects of recruitment, such as maintaining a personal touch in candidate interactions.

Bajzikova and Smerdova's paper [81] highlights critical ethical and legal challenges in AI-powered RPA for recruitment, particularly regarding data privacy and compliance with the General Data Protection Regulation (GDPR). According to the paper, businesses need to make sure that any automated methods for profiling and making decisions comply to GDPR regulations, which include gaining applicants' explicit and firm consent before processing their personal data. It emphasizes the significance of openness in automated hiring procedures and the ban on the use of private information (including sexual orientation, political beliefs, race or ethnicity) in any way that can result in discriminatory actions. Furthermore, candidates must be informed about the purpose, methods and consequences of data processing and they retain the right to audit the data collected about them at any stage without barriers or fees.

Reference [86] discusses several challenges associated with the adoption of AI-powered RPA in recruitment. One major challenge identified is uncertainty regarding the correct choice of technology and the cost of implementation. HR managers often face difficulties in deciding which technologies to adopt and ensuring that the investment will yield significant returns. Additionally, resistance from employees and management toward these technologies is a barrier. Concerns arise regarding the impact on HR professionals' roles, with some fearing that the increasing reliance on AI and automation could diminish their professional value over time. This could result in technology that initially enhances competence but eventually leads to competence destruction as AI and RPA take over more tasks.

XI. AI DRIVEN RPA IN MANUFACTURING

The manufacturing sector is utilizing AI-powered RPA systems at a growing rate in order to increase productivity and efficiency by automating repetitive and manual processes that were previously conducted by human. Automation in manufacturing refers to reducing the requirement for human involvement in data entering process. IPA employs a variety of machines and robots to streamline production processes with the aim of increasing production capacity and reducing costs. By replacing human labor with industry-specific robots manufacturing companies use RPA-based systems for crucial tasks such as product assembly, quality monitoring and packing. According to [87], the combination of RPA, AI and machine learning in automation is referred to as Hyperautomation.

A. APPLICATIONS AND USE CASES IN MANUFACTURING

In [67], the author has mentioned several uses cases of intelligent automation in manufacturing. Some of them are listed below:

1) PRODUCT TRACKING

Product tracking is an approach that is used to measure, analyze and advance visibility across the manufacturing process. Using intelligent automation, manufacturers can create an almost real-time visualization of progress of orders and ongoing needs of components and materials. This helps manufacturers optimize their process, utilize resource and keep margin low.

2) BILL OF MATERIALS

Maintaining an accurate bill of materials (BOM) is crucial for manufacturers because it gives them information about the parts, sub-components, intermediate assemblies, raw materials and their corresponding amounts that are required to make a high-quality final product. Manufacturers can effectively gather product data and replicate the human procedures required to build an accurate BOM quickly and with little errors by utilizing intelligent automation.

3) CUSTOMER SERVICE AND SUPPORT

Enhancing purchase order processing, delivering responsive customer service and improving quality assurance are key to increase customer satisfaction. Sysco is the world's largest distributor of food and related products. They demonstrate how intelligent automation can enhance customer service. To do so, they integrated intelligent automation into its distribution network to provide better service to its 600,000 client. When the pandemic strained global economies, Sysco expanded its automation to include over 60 digital workers. This expansion enabled the processing of 6.2 million transactions which saved the company over 250,000 work hours.

4) PERFORMANCE REPORTING

Digital workers are capable of generating reports that showcase regulatory compliance and adherence to service level agreements (SLAs). ABB, a Swiss industrial manufacturing leader, utilized intelligent automation to compile and produce more than 200 reports every morning. This gives employees in over 25 countries the insights necessary to enhance their performance.

5) QUOTE MANAGEMENT

Intelligent automation allows manufacturers to automatically generate on-demand quotes that reduces delays and enhances customer experience. AGCO utilized intelligent automation to manage its essential quotation process which is vital for their revenue generation. Previously, staff spent significant time completing each quote. Therefore, AGCO aimed to optimize this process to allow employees to focus on negotiating better contracts. Now, when a quotation request is received, a digital worker reads the email, retrieves the necessary data, updates the systems and sends the quote. This automation has saved thousands of hours and helps staff to concentrate on more valuable tasks.

6) SUPPLY CHAIN DEMAND PLANNING

Forecasting the demand for goods and materials across different regions in the supply chain requires strong digital integration. Supply chain automation eliminates silos and provides insights to ensure that goods and materials are available where needed. Norsk Stål, a leading supplier of steel and metals presented the potential of RPA and intelligent automation in supply chain demand planning. Across their facilities, a team optimizes steel product manufacturing to meet customer deadlines and reduce waste. Each day, production planners sends an estimate of the plants' maximum workload to the automated system. The system then retrieves approved orders for steel products from their ERP system, calculates the optimal production schedule, and prepares a manufacturing plan for the plant before the morning shift begins.

Reference [88] presents a case study in the manufacturing industry that involves the automation of sending out production orders to a fabric finishing plant by developing artificial intelligence on RPA. This allows optimization in the allocation and cutting of fabric rolls which is a primary raw material in the process. The steps of the framework is presented in figure 16.

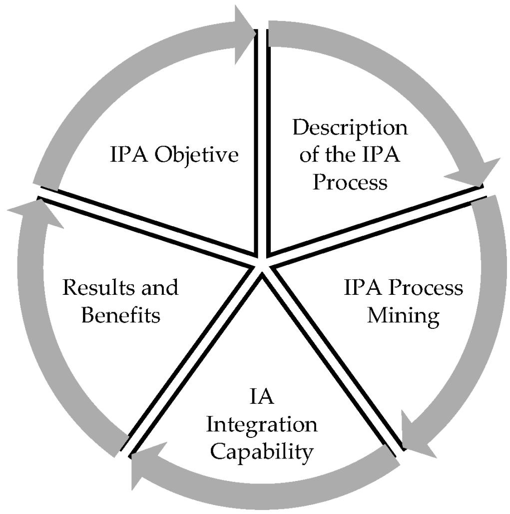

FIGURE 16. Instructional sequence for AI and RPA in manufacturing [88].

a: IPA OBJECTIVE

The purpose of this step is to create purchase orders for fabric stamping. Here, RPA robot follows a templated process to create the purchase order in SAP and generate an email response by attaching the order in a PDF format.

b: DESCRIPTION OF THE IPA PROCESS

The process starts with receiving a customer email which includes a file that has fabric purchasing requirements such as quality, color and type. This information is initially validated before being sent to the Orchestrator to activate the robot. If there are pending orders, the robot logs into SAP and creates an order by inserting all the information into an SAP transaction.

A major challenge occurs if there is an exception or business rule. The robot has to choose from a pool of available fabric rolls while optimizing the selection to minimize waste in fabric rolls. To address this, an AI algorithm was integrated into the RPA system to enhance decision-making which eventually allows for faster selection of fabric rolls. After exploring different options of integrating AI algorithms into RPA, they found that inserting code directly into robot's programming was the best option. This way, robot remains aware of its input and output. After deciding on the most optimal selection of fabric rolls while following the business rules and requirements, the robot creates a purchase order in SAP. At the end, it creates a PDF file and saves it in a specific folder that follows a specific name convention and sends to organizational manager via email.

c: IPA PROCESS MINING

In this step they have described the sequence in which IPA carries out its tasks. They also mention exceptional cases where error may occur for example, when RPA robot receives an email it validates its information with the existing materials inserted in SAP. If information doesn't match, it sends out an email including the reason behind the error to a desired mailbox. The information that are sent to RPA Orchestrator are: material, delivery cycle, value, brand, quality, the quantity of fabric required, ID of the fabric supplier, minimum quantity to take, and priority of the order, among others.

d: AI INTEGRATION CAPABILITY

The AI component optimizes batch selection and ensures that certain business conditions are met, such as selecting rolls from the same batch, avoiding the splitting of rolls from external suppliers, and preventing rolls from being left with less than 50 meters. The system manages order tolerances by allowing a maximum of 10% additional fabric for requirements up to 600 meters, 6% for 601 to 1000 meters, and 2% for over 1000 meters. The AI component, was written in Python programming. It was integrated with RPA through a built-in activity that converts Python code to .NET code. It helps enabling to monitor error within the robot platform. By combining AI and RPA with specific business rules, the automation gains decision-making capabilities. This allows the software to make optimal decisions that aligns with business expectations.

e: RESULTS AND BENEFITS

The implementation of IPA resulted in the following impacts:

- Two employees' time was freed up.
- The time spent processing each order was reduced from 12–15 minutes to 5.1 minutes.
- The integration of AI software decreased fabric waste by 30% which leads to economic benefits.
- The IPA's order prioritization helped meet urgent needs and improved the efficiency of the processing pipeline.

B. CHALLENGES: MANUFACTURING

The integration of AI-powered RPA systems in manufacturing presents several specific challenges, particularly in areas such as product tracking, supply chain demand planning and production automation. One of the key challenges is ensuring the accuracy and consistency of data throughout the manufacturing processes. Automated systems heavily rely on data integrity for tasks such as bill of materials (BOM) and product tracking. Any inconsistency or error in data could result in production delays, increased costs or faulty products. For example, as seen in the implementation of AI in fabric roll allocation, errors in data validation or processing could disrupt the entire workflow, causing significant inefficiencies [89].

AI integration in manufacturing, such as in Norsk Stål's supply chain demand planning, requires real-time decision-making that often involves complex business rules. Ensuring that AI systems can make accurate and optimal decisions in such dynamic environments remains a significant challenge. This becomes especially difficult when balancing multiple factors, such as resource allocation, delivery schedules and production constraints [32].

As AI systems become more deeply embedded in manufacturing, ensuring scalability and flexibility to accommodate growing production needs and varying business conditions becomes a challenge. The integration of AI in fabric roll optimization, for instance, must account for changes in production volume, materials, and external market factors without significantly disrupting operations [90].

Another challenge lies in effectively integrating AI-powered RPA with existing enterprise resource planning (ERP) systems, such as SAP. In complex processes like

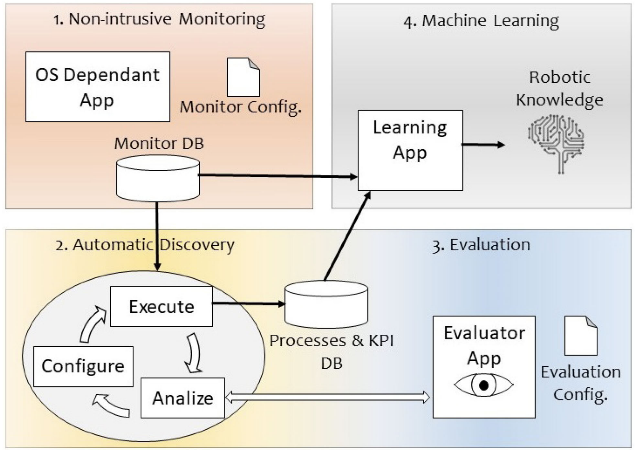

FIGURE 17. A global view of RAIL project [92].

fabric roll allocation, seamless integration between AI, RPA, and ERP systems is critical for maintaining operational efficiency. Discrepancies or integration failures can lead to order mismanagement or delays, impacting the overall productivity [91].

AI-powered RPA systems in manufacturing are designed to reduce human labor; however, achieving an optimal balance between automation and human oversight presents challenges. Ensuring that humans remain involved in key decision-making processes, particularly when dealing with exceptions or complex business rules, is essential for the success of these systems.

XII. ANOTHER REAL AI POWERED RPA PROJECT FOR BACK OFFICE

Several organizations have embraced RPA to advance the technology they use for back office. As discussed so far, the current trends mostly lie in infusing a loop called ''human-in-the-loop'' which supports human interaction with robot. This is important as most RPA bots need human interaction to some extent.

1) USE CASE 1

Reference [92] demonstrates a real project called ''RAIL'' which is developed by Servinform Inc. and the University of Seville. The aim of this project is to identify and automate business processes from back office without disrupting the existing system. It is made of a series of modules which is depicted in figure 17.

a: NON-INTRUSIVE MONITORING

First of all, RAIL creates a document to capture a structured dataset in real time from the interaction between user or computer without hampering anyone's activity from back office, breaching security and jeopardizing confidentiality of the data. It uses a non-intrusive monitoring software to capture the data.

b: AUTOMATIC PROCESS SURVEY MODULE
Then it includes an automatic process survey module to create workflow variants from logs and images collected from previous step using image-hash, image-match and OCR algorithms.

c: QUALITATIVE EVALUATION MODULE
The automatic survey of the process goes through a number of evaluation and fine tuning by changing different parameters of algorithms. This helps to improve the process. The integration of PoM software helps users to implement process generation algorithms and determining evaluation matrices as output. The outcome is an accurate demonstration of the executed process which highlights the edge or exceptional cases that are typically more difficult to find. It is important to identify such cases as it may lead to failure in robotization.

d: MODULE FOR THE IDENTIFICATION AND DEPLOYMENT OF PREDICTIVE ALGORITHMS
This module includes the learning components and the predictive components. A neural network based model is utilized to learn from user inputs such as mouse click, keystrokes, text and so on to convert the tasks into a corpus. Once the model is trained, it can be used to predict robot's behavior so that RAIL can be asked for the next course of actions.

A. CHALLENGES: BACK OFFICE
The RAIL project and similar AI-powered RPA systems in back office processes face several key challenges as well. Non-intrusive monitoring techniques as employed in the RAIL project, raise concerns about data privacy and security. Although designed to avoid disrupting user activities, ensuring that the data collected through such monitoring remains confidential and compliant with regulations like GDPR is a persistent challenge [93]. The ability of AI systems to handle complex business processes and identify exceptions, such as unexpected input during automated tasks remains a significant challenge. AI algorithms must be robust enough to manage variations in data and workflows and errors in predicting robotic behavior that can cause system failures or inefficiencies. Developing effective predictive models to optimize robotic actions, as seen in the RAIL project, requires extensive training and data collection. Ensuring that neural networks and other AI models can accurately predict future tasks without significant error is a key challenge, especially in dynamic back office environments where manual input can still be necessary [94]. Integrating AI and RPA systems with existing back office infrastructure while ensuring seamless automation across various processes can be a daunting task. Managing exceptions and ensuring that AI-driven systems do not interfere with established workflows requires meticulous planning and ongoing adjustments [32].

Organizations should use end-to-end encryption and anonymization solutions to address data privacy issues in non-intrusive monitoring and guarantee compliance with GDPR and other regulatory standards. AI models must include methods for continuous learning that adjust to changes in workflow and take unexpected inputs into account in order to handle complicated processes and exceptions. When data scientists and domain specialists work together, domain-specific information may be incorporated into AI algorithms, increasing the predictive models' resilience. AI and RPA must be seamlessly integrated with current infrastructure, which calls for modular designs and phased implementation tactics that minimize interruptions and permit gradual adaptation. AI systems may maintain alignment with organizational procedures and provide reliable performance without sacrificing security or efficiency with regular audits and feedback loops.

XIII. OPEN RESEARCH CHALLENGES
Based on our in depth review and survey we have identified the following areas where there are limited work or lack in research is noticeable:

A. CHANGE MANAGEMENT AND COMMUNICATION STRATEGIES
To adapt IPA technology in any organization, it is needed to make changes in change management through proper communication. Wherever, there is a need for digital transition, the structure of the team needs to be changed. If we combine technologies like RPA and AI then there should be an open communication channel between RPA team and AI engineers. While RPA team will take care of managing bots, their subscriptions and other configurations, AI engineers will focus on developing suitable ML models to advance the process. The whole process needs strategic movement, discussion and communication.

B. ETHICAL AND LEGAL CONSIDERATION
The data-driven nature of IPA raises important ethical and legal questions. This is particularly related to data privacy and algorithmic bias. It is important to do research into developing ethical guidelines and legal frameworks that address these issues. Ensuring that collecting data through RPA process is not impacting data security, AI algorithms are transparent, fair and compliant with regulations is crucial to gaining people's trust and ensuring the ethical deployment of IPA technologies.

C. SELECTING ML MODELS
Data curation is an important part of IPA process. Also, accessing to data through ML models is a significant step. However, there has not been much research on the selection process of ML models. Selecting biased or not suitable models will have negative impact on the output of IPA process. There is a pressing need for research on listed models in RPA tools. An open documentation on selecting optimal models for particular use cases should be published.

D. EXPLAINABILITY

One critical challenge in the IPA process is the need for Explainable AI (XAI). Reference [95] defines XAI as a suit of techniques and algorithms designed to advance the trustworthiness and transparency of AI systems. The goal of these technique is to explaining the decisions or predictions of the models using several methods. As complex models such as deep learning models are now integrated with RPA, their black box nature can undermine the trust and prevent informed decision making. Research on XAI can focus on developing techniques that can balance model's accuracy with interpretability. By taking care of these challenges organizations will gain more trust on adopting IPA solutions and believe in its success.

E. FUTURE APPLICATIONS

Adopting AI has evolved and increased recently in agricultural sector too [96]. Earlier researches were based on crop yield with regression and clustering based analysis [97]. Now, there are advanced ongoing researches on water management, seed or soil analysis with Deep Learning techniques [98]. For example, [99] and [100] describes how drones are used to collect image data from crop field which will eventually be used by vendor specific applications to analyze. However, predicting crop yield is one of the fields where we have found limited research conducted purely based on IPA. For example, [101] has used RPA to collect data from different websites (weather, soil) to feed the data into predictive model to do crop yield analysis. As technology advances, integrating smart drones and RPA can significantly enhance agricultural practices. Smart drones can collect real-time data on soil moisture, temperature, crop health, and pest presence, which can be stored in a centralized database using RPA bots. These bots can automate data entry, ensuring timely and accurate updates. AI models analyze this data to assess soil conditions, predict crop yields and recommend appropriate fertilizers to farmers. Additionally, creating an AgroBot can be beneficial to answer basic questions related to planting, harvesting, and crop diseases which will provide farmers as well as local people expert advice.

With those data a model can analyze the soil condition, predict crop yield and recommend farmers for appropriate fertilizers. RPA bots can also inform farmers the exact time to use the fertilizers or pesticides by sending them alert. An agro bot can also be created for answering basic questions related to planting harvest or crop diseases.

Another future application can be, integrating RPA in applications using container technologies. This offers promising avenues for enhancing automation capabilities at the edge [102]. Containers, with their lightweight nature and flexibility, can facilitate deploying RPA processes on resource-constrained ARM-based edge devices, allowing automated tasks to be efficiently executed closer to data sources. This approach could significantly reduce latency and improve response times in environments where real-time data processing is essential. Research work [103] explores the potential and efficiency of container technology for AI application. They experimented with container for object detection application and shows that container is suitable for handling complex data.

XIV. CONCLUSION

Robotic process automation and artificial intelligence have come together to bring about a new phase of intelligent process automation, marking a significant advancement in the field of automation. In this paper we analyze how the integration of these technologies transforms business processes in several industries by incorporating cognitive capabilities into automation, rather than just automating repetitive activities. This change constitutes the core of the ongoing digital revolution under the name Industry 4.0, which is based on efficiency, precision, and adaptability.

RPA has broad application from enhancing productivity to reducing operational costs in the fields of finance, healthcare, manufacturing, and many other industries. But it actually sees its potent realization when subsumed into the application of AI, which brings along such abilities as data analysis, pattern recognition, and decision-making. Such synergy allows the automation of more intricate processes, thus letting businesses innovate and respond to market demands more effectively.

In this paper, we have discussed the journey that RPA has taken from its evolution and merging with AI to give insights into how it changes functions, from finance and banking to health, manufacture, and recruitment. Case studies and use cases have shown how AI-powered RPA is used to provide operational efficiencies, a better customer experience, and optimized decision-making. One such example is finance, where AI-driven RPA has modernized fraud detection and the processing of loans. Another one would be in healthcare, where it has revolutionized patient care and administrative workflows.

The benefits are clear, but there have been challenges following the implementation of AI-powered RPA. Some of these include data privacy, ethical considerations, bias in AI models, and complexity in integration with existing systems. This is only possible through multi-dimensional solutions, such as solid governance frameworks, relentless learning, and putting prime importance on transparency and accountability in AI-driven processes.

The future, or rather further transformation in industries, would be powered by AI RPA. However, it is extremely important to tread the waters carefully, whether within the ethical and legal environments, the kind of machine learning model used, and one needs to be explainable in order to trust the AI systems. With digital transformation speeding up, sectors like agriculture, at the very outset of massive technology adoption, offer fresh opportunities for growth and innovation.

In conclusion, the convergence of RPA and AI will determine the future of intelligent automation by enabling firms with the tools they need to drive efficiency, cut costs, and foster innovation. With this understanding of their synergetic potentials, businesses can unlock new opportunities and, as a result, maintain a sustainable competitive advantage in the fast-moving digital ecosystem.

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