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Robotic Process Automation in Manufacturing

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ABSTRACT

Robotic process automation (RPA) in manufacturing uses software bots to automate repetitive, rule-based digital tasks, improving efficiency and accuracy. It is a technology manufacturing businesses use to automate high-volume, repeatable tasks. It is increasingly becoming a key component of manufacturing and warehousing environments because it is helping manufacturing organizations do more with less. RPA can help enable manufacturers improve productivity, meet customers' expectations, and consistently drive product innovation-all while lowering costs. Manufacturers can integrate RPA bots on the production floor in addition to back-office operations. RPA in manufacturing is revolutionizing the way industrial operations are managed, optimized, and scaled. In this paper, we will discuss the role of RPA in the manufacturing industry.

KEYWORDS: *automation, robotic process automation, RPA, manufacturing, manufacturing industry.*

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INTRODUCTION

As the manufacturing industry grapples with ongoing labor shortages, high turnover rates, and increasing demand for skilled workers, companies are turning increasingly to innovative technologies. Robotic process automation (RPA) is emerging as a key solution to bridge the workforce gap, and optimize efficiency and precision. RPA is a critical innovation within Industry 4.0, or the fourth industrial revolution that blurs the line between the digital and the physical. The software executes a set of instructions to replicate tasks typically done by humans, enabling manufacturers to streamline operations, reduce costs, and minimize errors. Its impact on manufacturing is growing in several areas, including supply chain management, quality control, preventive maintenance, and administrative automation [1]. The manufacturing industry is expected to become a huge beneficiary of RPA technology due to the manual repetitive tasks that characterize traditional aspects of manufacturing. Figure 1 provides a definition of robotic process automation [2], while Figure 2 shows a typical manufacturing environment [3].

Robotic process automation (RPA) presents itself as a game-changing technology that enables manufacturers to boost efficiency, spur innovation, and automate monotonous operations. It is transforming the way organizations across different industries do business. It allows organizations to automate certain types of work processes to reduce the time spent on costly manual tasks and increase efforts to deliver mission critical work. It eliminates the need for employees to perform repetitive tasks by integrating software that performs the same set of steps as the employee. One of the main differentiators of RPA from other solutions is that it performs tasks that do not require deep cognitive capabilities. RPA software bots are used in manufacturing to automatically handle multiple rule-based operations like invoice and order processing, accounts payable and receivable management, bill of materials (BOM) updating, and others to eliminate repetitive manual tasks and improve the overall production lifecycle.

WHAT IS ROBOTIC PROCESS AUTOMATION?

Among the various forms of artificial intelligence, RPA stands out for its potential to significantly increase workforce productivity by reducing or eliminating the need to do repetitive tasks manually.

Popular applications of RPA include data entry, data reconciliation, spreadsheet manipulation, systems integration, automated data reporting, analytics, email notifications, acquisitions, administrative services, finance, human resources, mission assurance, strategic communications, travel reimbursements, claims processing, and customer outreach and communications. These are just a few examples of the ways RPA is being used to remove the burden of manual, repetitive, and duplicative tasks from public service workers [4].

Robotic process automation is a form of automation software. It is a technology that can automate repetitive, rules-based tasks. Like an Excel macro operating within a spreadsheet, RPA can record actions performed across a personal computer, access systems, and perform specific tasks for human users. It uses software robots, more commonly called "bots," that mimic basic human-computer interactions. Figure 3 shows the symbol of RPA [5], while Figure 4 shows processes that RPA can automate [6]. Most industries use RPA. The government does too. Due to the repetitive nature of some tasks, the probability of human error increases. One way to eliminate errors is by using RPA.

Robotic process automation solutions fall into three key categories: attended RPA, unattended RPA and hybrid RPA, as shown in Figure 5 [7].

Robotic process automation is a type of software that mimics the activity of a human being in carrying out a task within a process. It is a technology that automates repetitive tasks using software robots. RPA uses a set of automation tools to automate repetitive tasks and manual processes performed electronically. Since RPA can automate tasks that are rule-based, manual, repetitive, and tedious, delivering the highest levels of accuracy and eradicating human errors, it is a seamless fit for the finance industry. Here are some specific examples of what RPA in finance can do [8]:

- Opening emails and joining attachments
- Automatically logging into various applications on the web
- Shifting folders and files
- Copying and pasting
- Completing forms
- Collecting data from databases and the web
- Making calculations
- Connecting to system API
- Extracting structured data from documents
- Gathering stats from social media
- Following if/then decisions and rules

Some of these tasks are displayed in Figure 6 [7].

At its core, robotic process automation (RPA) is a tool designed to mimic rule-based business processes, performing them seamlessly and without fatigue. RPA is a rule-driven method that is limited in its application. The technology functions much like a Microsoft Excel macro; the key difference is in power and reach. It follows set rules, similar to how an Excel macro works, to do things like move files or log into accounts. Growing as a popular solution in finance and accounting, RPA refers to software technology or "software robots" with artificial intelligence (AI) and machine learning (ML) capabilities. The "software robots" have the ability to learn and complete a high volume of rules-based, repetitive tasks, and business processes. They have the capacity to operate much faster than humans, with 100% precision and reliability, working around the clock.

Finance and human resources are just two examples of departments likely to have many use cases that RPA can help solve. Some examples of good use cases for RPA in finance include processing customer orders, ensuring timely vendor payments, and managing period ending financial close processes. For human resources, some examples include employee onboarding, time tracking, and leave of absence management. Processes where human judgment is needed are not appropriate for RPA since RPA automations rely on clear, consistently applied rules [9].

Along with RPA, one should be aware of both business process automation (BPA) and digital process automation (DPA) – two commonly used automation technologies that robotics process automation can be paired to optimize and streamline a digital transformation. BPA refers to the use of technology to automate complex, multi-step workflows, typically very specific to a company's core business functions. DPA offers dual power by automating processes from end to end, and optimizing common workflows that involve external human interactions (i.e. sales, management). Separately, RPA and AI are quite powerful, but leveraging them together is undoubtedly advantageous to any financial institution. When deployed together, AI is the "brains" behind RPA's bots [10].

ROBOTIC PROCESS AUTOMATION IN MANUFACTURING

The manufacturing industry is one of the more complicated and labor-intensive industries. It is an ever-changing industry where technological advancements are reshaping operations and challenging traditional production models.

Automation in the manufacturing sector has long outperformed manual processes in gathering relevant data, visualizing all critical production KPIs, and then delivering final reports to the right stakeholders. However, when compared to other industries like banking, financial services, insurance, and retail, the manufacturing industry has been slower to deploy software automation in core manufacturing processes of production, operations, and maintenance.

Before automation, a manufacturing company receives hundreds of invoices from various suppliers each month. Employees manually input invoice data into the enterprise resource management (ERP) system, verify details, and process payments. Completing tasks manually is time-consuming, error-prone, and far from creative yet vital to keeping the factory running. After automation, an RPA bot handles the end-to-end process in seconds. Bots do them all way faster and without lapses. RPA involves creating a set of instructions that guide the software robots to perform specific tasks.

Robotic process automation (RPA) has emerged as a transformative technology, offering significant advantages to manufacturers seeking to streamline operations, reduce costs, and improve overall productivity. It uses software robots to automate repetitive, rule-based tasks traditionally performed by humans. These tasks can range from data entry and processing to complex calculations and report generation. By automating repetitive and rule-based tasks, RPA significantly reduces the burden on human labor, allowing workers to focus on more strategic and value-added activities. With RPA in manufacturing, you bring the benefits of precision and speed to your human-powered workflow. By implementing RPA, manufacturers can automate routine processes and achieve faster, error-free, and consistent results. Figure 7 is a representation of RPA in manufacturing [11].

APPLICATIONS OF ROBOTIC PROCESS AUTOMATION IN MANUFACTURING

RPA bots can automate a range of operations. Tasks related to inventory management and order processing, supply chain management, quality control, production monitoring, compliance and reporting, and invoice processing are most suitable for RPA-enabled automation. RPAs can be deployed in diverse forms to automate more complex processes across industries such as manufacturing, finance, and healthcare. HR, finance, and customer support departments also benefit from deploying RPA to automate manual processes. Common applications of RPA in manufacturing include the following [0,12-15]:

- *Manufacturing Automation:* This includes using advanced technology, including robotics, vision, and software, to streamline and optimize production processes. Manufacturing automation can take many forms, such as using autonomous robotics to handle parts and products in strategic areas. It can also include using artificial intelligence and high-speed cameras to find errors in products. Automation has become synonymous with using robotics and machines to reduce or replace work traditionally done by employees. But robotics is only one part of how automation works in the manufacturing industry. Controls engineers can program robotics to do the same task the same way every time, or, using more advanced technology, they can program them to be more flexible. Manufacturers who install robotics and automation solutions into their production lines can improve productivity, accuracy, repeatability, and quality. Figure 8 shows a typical example of manufacturing automation [16].
- *Administration:* This is one of the most fundamental examples of RPA being used to perform routine tasks. Manufacturing companies face plenty of issues when it comes to processing that can result in a considerable overload upon the administration departments. This is where RPA serves as the magic wand for dealing with effectively managing administration. Tasks manufacturing administrative tasks are time-consuming. Employees can concentrate on other crucial tasks when these reduce in importance. The manufacturing industry has a lot of administrative tasks that get automated. Tasks that are simple to automate include attendance, action items, and meeting minutes.
- *Supply Chains:* Coordinating supply chain activities, such as procurement, logistics, and transportation, involves managing multiple processes and stakeholders. Due to global geopolitical tensions, a supply chain may become a roller coaster for manufacturers. Supply chains have faced unprecedented disruptions in recent years, impacting manufacturers and logistics providers alike, along with their customers. Automation is transforming supply chains by enhancing efficiency, accuracy, and resilience in manufacturing operations. Within supply chain management, RPA can automate procurement, supplier management, inventory tracking, shipment tracking, supplier communications, and more, integrating with enterprise resource management (ERP) systems to reduce manual data entry. This speeds up invoice processing and

purchase order approvals, and it optimizes logistics and freight scheduling.

- *Order Tracking*: Busy manufacturing teams can receive thousands of orders per month. RPA can help process and fulfil these orders by automating the entire process. Automating repetitive tasks in order tracking facilitates transparency in managing the flow of goods from the production line to the warehouse. RPA bots can track the status of shipments from suppliers in real time using tracking numbers, generate automated alerts for any delays or deviations from expected delivery times, and update internal inventory systems upon receipt of goods.
- *Data Management:* One of the biggest challenges in manufacturing is making sense of the vast amounts of data generated during production. Robotic process automation is great for the data management of an organization. RPA bots can collect, process, and analyze this data instantaneously. Data management involves the collection, validation, storage, protection, and processing of data to ensure its accessibility, reliability, and timeliness. RPA can automate data management tasks, such as data entry, data validation, and report generation. For example, an RPA bot can be programmed to automatically enter data into a system, validate it against predefined rules, and update the system with the validated data. The bot can generate reports based on the data, providing timely and accurate insights into various aspects of the manufacturing process. The bot can also validate the migrated data to ensure its accuracy and completeness.
- *Procurement Management:* Poor procurement data quality and a large number of operational tasks are the major challenges for procurement departments. RPA can help tackle these issues and contribute to the optimization of procurement operations within a manufacturing enterprise. After approving the vendor, procurement specialists can use RPA bots to generate contracts using prebuilt templates and vendor data, including the billing address and preferred payment period. RPA bots are also used to automatically set up new vendor accounts in the ERP.
- *Inventory Management:* The manufacturing industry has a lot of paperwork in inventory management. Inventory management is a fundamental part of manufacturing operations. Real-time monitoring of inventory levels is required to ensure that demand can be met. Inventory management is the activity of supervising and managing the movement of products into and out of a company's inventory. It is possible to automate inventory monitoring, stock-level notifications, and product reordering when the levels go below a set threshold. All this can be done with minimal human intervention. RPA in manufacturing provides inventory managers with real-time data about the inventory levels so that they can monitor these levels and make better decisions based on historical data. RPA can automate inventory management by automatically updating stock levels, generating purchase orders when necessary, and sending alerts when stock reaches a predefined threshold.
- *Waste Management:* One of the most important aspects of reducing production costs is waste management. Manufacturers keep seeking ways to cut down waste in production. Waste management can benefit manufacturing businesses from RPA. By digitizing numerous repetitive processes with RPA, manufacturers can identify quality issues with their products. RPA monitors the waste produced during production and adjusts the process accordingly. The RPA bots are great at fixing manufacturing hurdles like manual lapses, inventory wastage, and process wastage. The rule-based execution of RPA solutions brings down occurrences of errors and increases accuracy. Subsequently, wastage in all forms is reduced too.
- *Predictive Maintenance:* RPA can continuously collect real-time performance data from connected equipment and feed this information to AI algorithms. RPA and AI can automate quality assurance processes on assembly lines. Computer vision powered by AI can visually inspect products for defects. RPA bots can then perform automatic reworking or removal of defective items. This results in higher and more consistent product quality with less human effort.
- *Customer Service:* Customer experience is one of the crucial aspects of the success of any business. In the era of experience-as-a-economy, customer experience is one of the most important parts of the business. Unreliable customer service management with manual customers' request handling leads to errors in tracking information and delayed response/resolution times leave customers unsatisfied. Resolving customer issues requires navigating through multiple business systems which is time-consuming and requires a lot of effort. RPA can be a help automating work in customer service, such as responding to common customer inquiries, updating customer

records, and processing orders and returns. Your deployment can automatically respond to customer emails or chat messages that contain certain keywords, providing quick and consistent responses.

- *Bill of Materials (BOM):* The bill of materials is an important document that highlights what parts need to be manufactured. BOM is a central document in the manufacturing industry. It consists of a comprehensive record of materials as well as components that are required for creating a new item or product. The main aim of the document is to provide employees with all the data they require regarding their journey towards the advancement of new products, that is information focusing on what, when, where, as well as how to buy. RPA, equipped with its ability to conduct quasi error-proof task function, becomes a crucial requirement as it is programmed for precise and timely process completion. RPA technology allows for real-time management of the bill of materials. It ensures that everyone is on the same page and that any adjustments or changes are reflected in a single source of truth.

BENEFITS

RPA brings tangible benefits to companies across all industries, including manufacturing. The automation of mundane tasks enables companies to free up human workers to focus instead on innovation and problem-solving. In other words, manufacturers can reduce human intervention in repetitive tasks while using workers for more value-added responsibilities. This leads to increased productivity, significant cost savings, and enhanced decision-making through real-time data insights. Other benefits include the following [3,17]:

- *Cost Savings*: By saving hundreds of human workers' hours, RPA helps manufacturers decrease operational costs to free up financial resources for strategic initiatives. Wiping out costly errors and freeing up staff from mundane duties makes RPA an instrumental add-on to your cost-reduction strategy. Typical savings on current operational costs range from 25% to 80%, which can translate into tens of millions of dollars annually for some organizations. The speed and accuracy of automation help reduce administrative, prevention, appraisal, and internal/external failure costs.
- *Regulatory Compliance:* Manufacturers must adhere to several regulatory requirements. RPA can compile compliance data, generate reports, and even send them to regulators automatically minimizing non-compliance risks. Apart from RPA-driven cost reduction, organizations also reap benefits like improved compliance, recognizing the impact of the technology on enhancing efficiency. With RPA's capability to cross-reference raw materials and testing results against regulatory requirements, update compliance documents in real time, and, overall, facilitate adherence to regulations, meeting even stringent standards. Governments around the world are enforcing stricter regulations on goods, with tight restrictions on various parts and practices.
- *Increased Productivity:* RPA transforms how dozens of routine but critical tasks are handled. The tireless digital workforce completes these tasks in seconds with near-zero error rates. Automation can be especially helpful when organizations experience a labor shortage. Any way you slice it, the outcome is freeing up thousands of labor hours yearly and increased productivity as workers focus on higher-value, meaningful work.
- *Improved Quality:* Enhanced quality control is one of the most immediate benefits of RPA. High quality is always a matter of a strong reputation and profitability. Traditional bill of material (BOM) management often suffers from manual errors. Incorrect quantities or assembly instructions, inconsistent updates, and difficulty tracking changes lead to defective products, wasted resources, and costly rework. Automation software accurately updates BOM data and transfers it into ERP systems, making sure nothing is overlooked, even when changes occur. In production lines, RPA maintains stringent quality specifications, reducing defects in final products. Bots consistently perform quality inspections, minimizing the risk of human oversight.

CHALLENGES

While RPA brings numerous benefits, manufacturers should be aware of potential challenges. RPA software is static; it is not improved or changed based on the inputs or its results. Introducing RPA often requires a cultural shift within the organization. Employees may perceive automation as a threat to their jobs or may resist changes to established processes. One of the most common misconceptions about automation is that it will replace human workers. However, the reality is quite different. Other key challenges include the following [17]:

- *Complexity*: Manufacturing processes can be highly complex and interconnected, involving

multiple systems, machines, and departments. Identifying and automating these processes requires a deep understanding of workflows and dependencies, which can pose challenges during implementation.

- *Limitations*: RPA handles repetitive, rule-based tasks with organizations. However, there are plenty of tasks that are less suitable for RPA, such as processing unstructured data or mimicking human decision-making. However, when augmented by AI, cognitive RPA can perform a blend of human and computer tasks, widening the scope of possible benefits within the manufacturing sector.
- *Legacy Systems*: Many manufacturing facilities still rely on legacy systems and equipment that may not be compatible with modern RPA technologies. Integrating RPA bots with existing IT infrastructure and ensuring seamless communication between different systems can be a technical challenge. RPA is adept at bridging the gap between legacy systems and modern infrastructure
- *Data Security:* Manufacturing operations generate vast amounts of sensitive data related to production, inventory, and customer information. Ensuring data security and compliance with regulatory requirements while handling and processing this data through RPA systems is crucial but can be complex.
- *Skill Gap*: Implementing RPA requires skilled personnel who can design, develop, deploy, and maintain automation solutions. Finding individuals with expertise in RPA tools and technologies, as well as providing ongoing training for employees, can be a challenge for manufacturing organizations. With the right investment, manufacturing management teams can ensure that delays caused by understaffing are a thing of the past while ensuring their productivity and efficiency grows as more processes are automated.
- *Scalability:* Over time, the manufacturing organization can be looking to scale its automation initiative, and the existing RPA solution may not be able to accommodate this growth. When choosing RPA technologies, manufacturing companies should evaluate the scalability of the potential platform.

FUTURE OF ROBOTIC PROCESS AUTOMATION IN MANUFACTURING

It is fascinating to consider how RPA could change the manufacturing sector in the future to deliver better products at lower costs. The ultimate goal for automation in manufacturing is not to automate a single task, but an entire process-and that requires multiple technologies, not just RPA. You need comprehensive, intelligent automation that uses a combination of RPA, AI, IoT, machine learning, and other technologies. The future of RPA in manufacturing promises deeper integration with these technologies, especially with artificial intelligence and IoT devices, automating complex workflows with minimal human intervention, minimizing errors, and further driving innovation and efficiency. Traditional RPA automates rule-based, repetitive tasks, but when combined with AI and ML, it evolves into intelligent automation (IA). These technologies can be combined and used as key enablers for end-to-end process automation [18].

Automation and robotics solutions in manufacturing are expanding and will continue to change the manufacturing plant. The global manufacturing industry will face significant business obstacles in the coming years. International supply chain uncertainty, tax and transfer pricing reforms, a push for sustainability, a shortage of raw materials and components, and ageing IT infrastructures are among these. The future of labor in manufacturing is one where human ingenuity and robotic efficiency coexist. By embracing manufacturing automation, companies are not only addressing the immediate concerns of labor shortage and retention but are also investing in a future where their human workforce can engage in more strategic, creative, and technically demanding roles. As we look to the future, it is evident that the harmonious integration of human and machine labor is an achievable reality that promises to sustain the industry for generations to come [19].

CONCLUSION

Robotic process automation (RPA) is a technology that uses software robots to automate and streamline repetitive and rule-based tasks in various business processes. At its core, RPA involves creating a set of instructions that guide the software robots to perform specific tasks. The key advantage of RPA lies in its ability to perform tasks faster and more accurately than humans. In manufacturing, these tasks can range from data entry and reporting to routine inspections and quality control. Manufacturers are actively adopting RPA to automate voluminous and repetitive tasks that constitute their daily routines. RPA are reshaping manufacturing operations and driving unprecedented efficiency. RPA is here to stay.

In today's era of digital transformation, RPA is not just a competitive advantage it is becoming a core pillar of modern manufacturing strategy. The next

evolution of RPA is intelligent automation, which involves combining RPA with AI, machine learning, and predictive analytics. The future of manufacturing lies in the intelligent integration of these technologies. This allows bots not just to follow rules, but also to learn from data and make decisions. Add artificial intelligence (AI) and machine learning (ML) into the mix, and RPA can be taken to new heights.

Integrating robotic process automation is becoming a cornerstone in the modern manufacturing landscape, offering efficiencies that were previously unattainable.

This technology, once perceived as futuristic, has now become an essential tool for manufacturers aiming to stay competitive in an increasingly fast-paced market. The ability of RPA to automate certain repetitive, predictable, and rule-based processes traditionally handled by humans makes it a sought-after technology. It minimizes human errors and boosts business efficiency and productivity. It is becoming increasingly popular as a way for businesses to increase efficiency, cut expenses, and improve output.

More information about robotic process automation in manufacturing can be found in the books [20-25].

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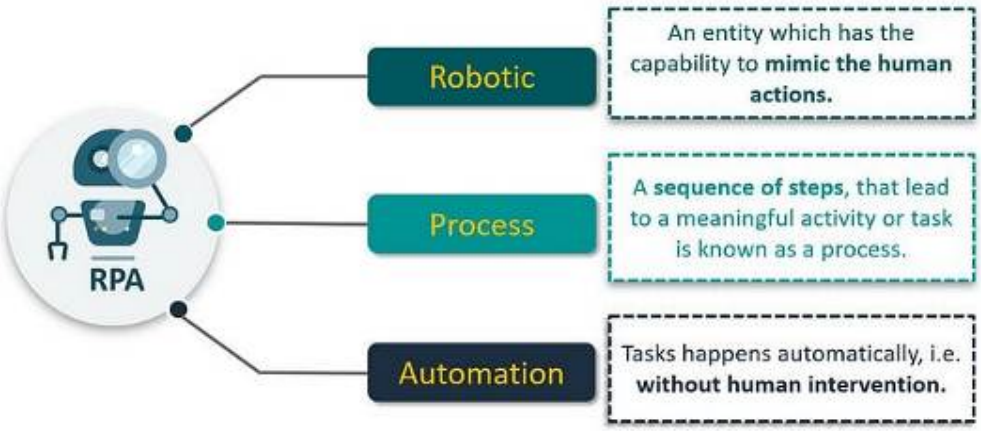

Figure 1 A definition of robotic process automation [2].

Figure 2 A typical manufacturing environment [3].

Figure 3 Symbol of RPA [5].

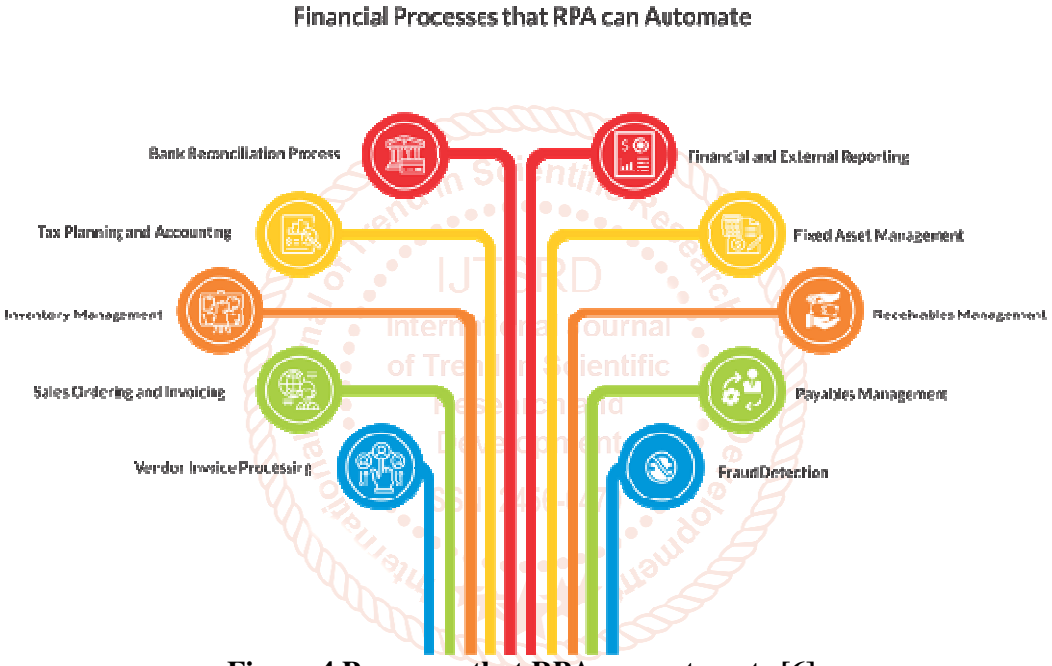

Figure 4 Processes that RPA can automate [6].

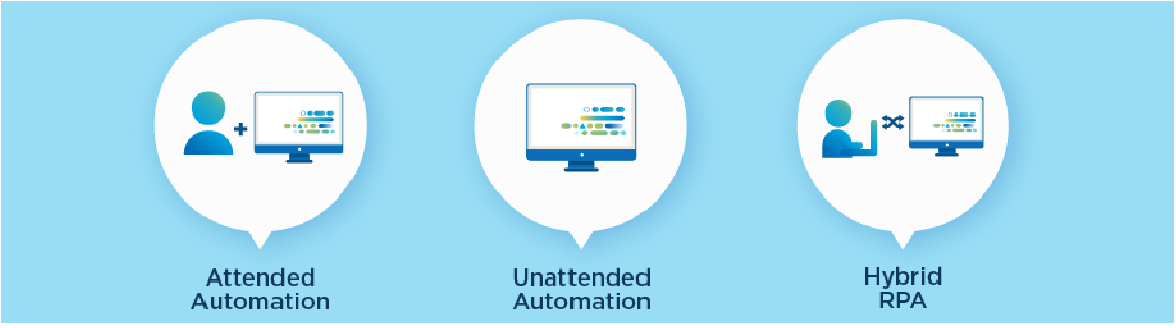

Figure 5 Three key categories of RPA [7].

Figure 6 Some tasks RPA can perform [7].

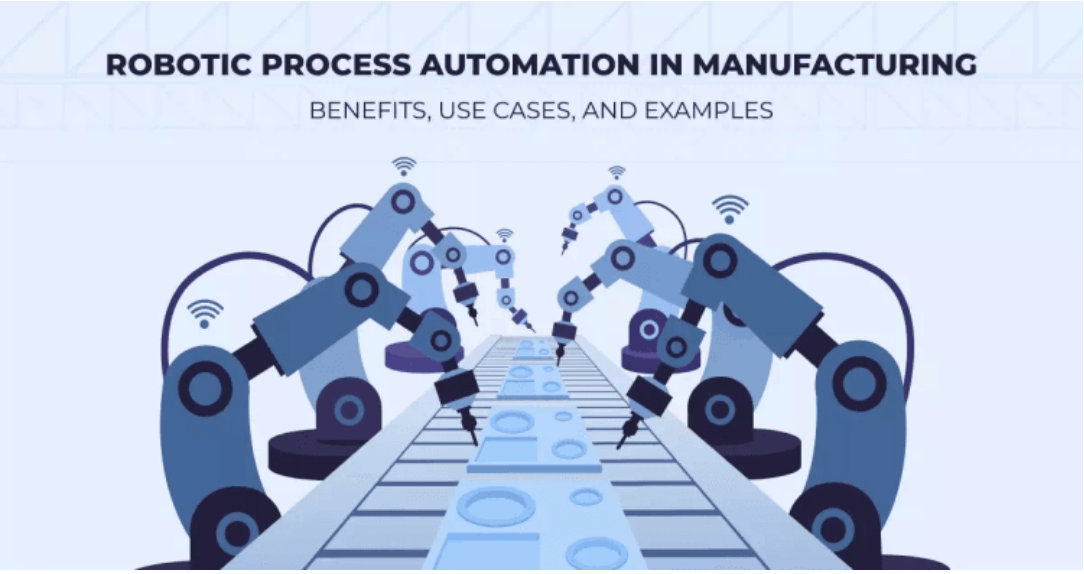

Figure 7 A representation of RPA in manufacturing [11].

Figure 8 A typical example of manufacturing automation [16].