Integration of IT Systems Using QR Code and IPA in Logistics Process Management

Izabela Kudelska
Poznan University of Technology,
Faculty of Engineering Management
2 J. Rychlewskiego, 61-965 Poznan, Poland
izabela.kudelska@put.poznan.pl

Mariusz Piechowski
WSB Merito University in Poznan,
Powstańców Wielkopolskich 5,
61-895Poznan, Poland
mariusz.piechowski@poznan.merito.pl

Abstract

In the face of the growing complexity of supply chains and the variety of IT systems used in enterprises, ensuring effective information exchange is a challenge for companies. The research problem addressed in this work is the lack of an effective mechanism for automatic identification and matching data between systems. Therefore, the concept of using QR code technology and IPA systems was proposed. A case study was used to verify the concept. The implementation showed precise product identification, automatic document generation and delivery status update.

Keywords: QR code, IPA, digital transformation

1. Introduction

Information systems and automation facilitate collaboration between company departments, such as purchasing, production and distribution, and supply chain integration. They ensure communication and coordination between suppliers, manufacturers and buyers [11]. Automation not only increases productivity, but also improves product quality, reduces labor costs and increases safety [1], while reducing inventory and logistics administration costs [15]. Technologies such as QR codes, RFID, GPS enable automatic monitoring of products and fleets. SOA supports supply chain coordination, and AI enables analytics and forecasting [4]. However, IT and automation implementation are associated with challenges, such as data protection, privacy, process changes, and employee resistance [2], [13]. The lack of clearly defined processes, responsibilities, and strategies can make it difficult to implement and manage systems. Data standardization and adapting technologies to diverse products and processes are also problematic [9]. Many systems are not fully automated, and integrating new technologies can be expensive and complicated. There is also a lack of commonly accepted standards that would enable smooth communication between systems.

The aim of this work is to investigate how the integration of QR codes with intelligent business processes (IPA) can improve the exchange of information between inconsistent IT systems. The research problem concerns the lack of effective mechanisms for automatic data matching, which leads to delays and errors. The aim is to develop a system that does not require full IT integration but allows for the automation of logistics processes.

Paper structure: Section 2 introduces IPA and QR technologies and their role in the supply chain. Section 3 describes the research approach, Section 4 presents the integration concept, Section 5 provides a discussion, and Section 6 summarizes the conclusions,

limitations, and directions for future research.

2. Analysis of the literature on the subject

QR codes are widely used to track products in the supply chain. Each product receives a unique QR code that stores updatable information at each checkpoint, enabling real-time data access across the supply chain [23]. QR codes are often integrated with blockchain technology to verify product authenticity [21].

QR codes automate many supply chain processes and are categorized into standard, improved, and specialized codes. Standard QR codes include static codes with permanent data and dynamic codes that allow data updates without altering the code itself [26]. Improved QR codes, such as those with embedded images or encrypted data, enhance branding and security [5]. Specialized QR codes include color, 3D, and executable codes like eQR or sQR, which require specialized algorithms and offer high data density. 3D codes are used in manufacturing, while eQR and sQR codes can run applications on mobile devices without Internet access [16].

QR codes support a wide range of logistics applications. They help automate payments and improve operational efficiency [21], streamline inventory management, and reduce errors [17]. In logistics, they are also used for parcel sorting [7]. QR codes are often combined with NFC, RFID, blockchain, and augmented reality to enhance cargo tracking and product verification [6], [12].

Implementing QR codes alongside Robotic Process Automation (RPA) further boosts efficiency. Although the term RPA was introduced in 2012, its popularity surged in 2014 [27]. RPA automates rule-based business processes, and its integration with AI has expanded its capabilities to detect anomalies and forecast service demand [22], [24]. Literature highlights the benefits of combining QR codes with RPA for tracking, identification, navigation, and real-time data processing [3], [18], [20]. Additionally, integrating QR codes with AI improves automation efficiency [8].

The evolution of RPA into Intelligent Process Automation (IPA) through AI and machine learning allows automation of complex, unstructured tasks [28]. QR codes, when integrated with IPA, form the basis for intelligent logistics process management systems.

3. Research implementation process and research methods

The research process began with a literature review that provided information on the challenges and current approaches to integrating IT systems, QR codes, and IPA. Based on this, an integration concept was developed and then implemented in the company as part of the case study. The process is shown in Figure 1.

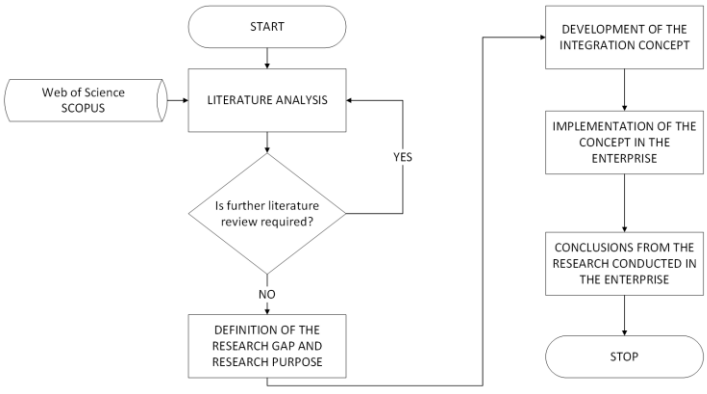


Fig. 1. Research procedure. Source: own work

The concept was implemented in a medium-sized company with 120 employees that produces aluminum die-cast products for automotive manufacturers in Europe. Production includes die-casting, machining, assembly, and shipping. Efficient planning and synchronization of processes is required, as the time-consuming casting process depends

heavily on punctual raw material deliveries and the condition of the equipment. Machining determines product quality, while in the assembly process, technological efficiency is crucial. This depends on automation, material availability, and the scheduling of all sub-processes. Delays can lead to delivery problems regarding punctuality, completeness, quantity, and traceability. Internal and external disruptions, such as outages or global events, further impact supply chain performance.

The implementation project included numerous optimizations in production, logistics, and work organization. However, this article focuses on resource identification, the automation of information management processes, and the efficiency of external logistics. These aspects illustrate the importance of technological integration for the flow of materials and information within the company and the supply chain. The authors' goal was to develop a system concept that eliminates the need for costly IT system integration, such as the exchange of information between ERP systems. Such integrations are expensive, time-consuming, and hardly feasible for many companies, especially when integrating multiple customers and systems..

4. The concept of system integration

The automotive industry places high demands on the supply chain, particularly in terms of timeliness, completeness and traceability of products. To meet these requirements, the supplier must effectively manage the entire production process. The analysis of waste and disruption factors carried out at the company revealed the following main problems:

1. Time losses in the delivery of standard parts and components to the assembly process due to long identification cycles, unfavourable storage locations and recording errors in the ERP system.
2. Disruptions in the assembly process due to inventory discrepancies, for example due to incorrect ERP data leading to assembly starting despite missing components.
3. Inefficient delivery processes due to long identification times, unfavourable warehouse organisation and errors in the ERP system.
4. Complaints due to incomplete deliveries due to incorrect identification and quantity discrepancies in the delivered products.

The analysis identified areas of action to increase logistics efficiency. These include:

1. Integration of identification systems between suppliers and the company to reduce unloading times and automate data capture.
2. Development of an internal resource identification system (materials, components, products, storage and fulfillment locations, and delivery information) to better monitor, manage, and automate logistics processes.
3. Implementation of a delivery identification system that shortens the time to release a delivery to customers by automatically confirming product completeness and traceability.

The project uses the JSON (JavaScript Object Notation) data exchange standard as the basic format for intersystem communication. JSON, a subset of JavaScript, is a universal, platform-independent text format characterized by high efficiency and readability of the notation, which enables efficient data exchange between heterogeneous applications [10].

The system concept covers three areas: integrated component supply lo, internal logistics resource identification system, intelligent supply identification and registration system.

1. Integrated management of deliveries of standard parts and components.

As part of the research work, a structured order document format was developed, containing unique identifiers used by the supplier and the recipient. Each order document transferred to the supplier (in electronic or paper form) is simultaneously published on the INTELOG platform (LOGISTICS INTEgration), which ensures transparency of the order fulfillment process for all stakeholders. In this way, the implementation of the system allows the supplier to precisely identify all assortment items of the order (taking into account the text description and photo visualization), automatically generate identification labels for individual items and the document, as well as update the delivery fulfillment status (e.g. "confirmed", "in progress", "fulfilled") in accordance with the industry standard ISO/IEC 15416:2016 [14].

On the recipient's side, the delivery verification process is initiated by scanning the QR code placed on the identification label (via the appropriate tag, e.g.: #ID$001), which automatically activates a dedicated bot (INTELOGBOT - LOGISTICS INTEgration bot). This component implements the algorithm for automating the process of verifying the completeness and compliance of the delivery, enters data into the ERP system, updates the delivery status on the INTELOG platform and generates an electronic confirmation of receipt of the delivery, which is forwarded to the supplier via e-mail.

2. Internal system for identifying logistics resources.

In the area of the internal system for identifying logistics resources, a standardized QR code format was developed, which allows for full automation of the process of disassembling deliveries of standard parts and components and is shown in Table 1.

Table 1. QR code structure and description of tags

QR code (JSON)	**Descriptions**
{	
"IDBOOT":"#ID$001",	Bot Initialization Key (Startup)
"Owner":"COMPOL",	Owner
"Contact":"www.compol.pl",	Link to contact details
"Document":	Document description section
{	Document type
"DocType":"DD",	Document name
"DocName":"Delivery",	Document number
"DocNo":"DD034|04|2025",	Date of issue
"DocDate":"12/04/2025",	Link to document
"DocNote":"www.compol.pl/DD/DD034|04|2025"	
},	Table of identifiers
"Identifier":[	
{	Type of identifier: product
"IdType":"Product",	Item number
"IdNo":1,	Index (designation): product
"IdItem":"AL-S06-0002",	Quantity
"IDQnt":12.000,	Price
"IdPrice": 34.56,	Link to product card
"IdNote":"www.compol.pl/AL-S06-0002"	Notes: Type of identifier may indicate: storage location, customer product index. Depending on the type of identifier, the Index tag may refer to other designations, e.g. the place of completion. Similarly, the link may identify a map of the storage location or a description card of the customer's product or a detail in the processing process.
},{	
…	
},{	
…	
}]	
}	

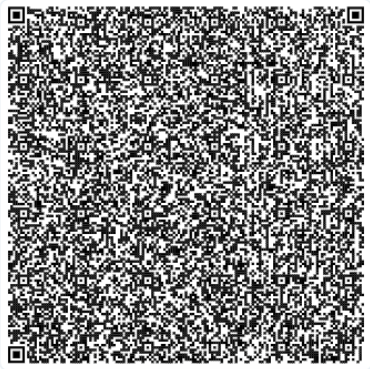
Source: own work

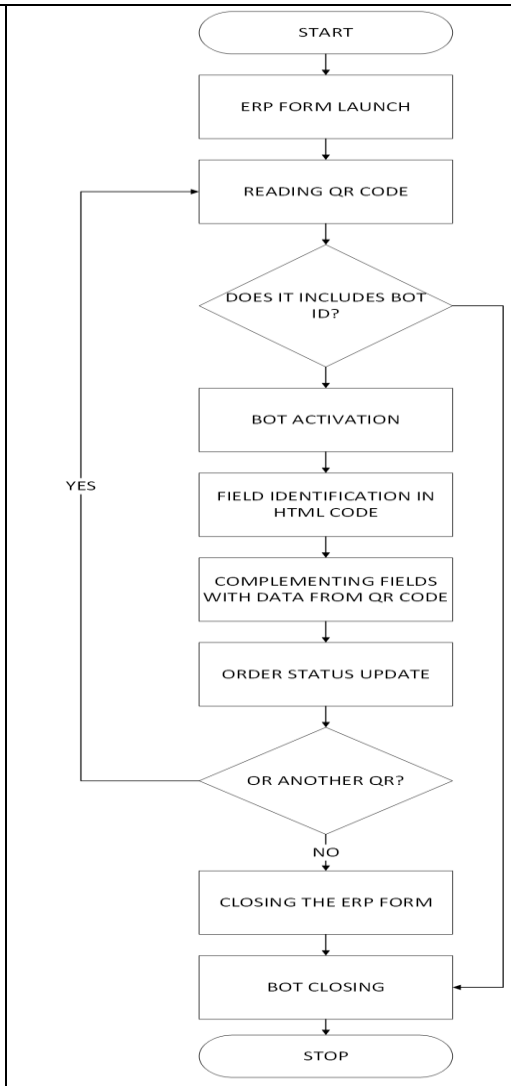
Scanning the QR code provided by the supplier launches the INTELOGBOT, which controls the process via an interactive control panel, displays the storage location, and confirms the operation. After scanning all relevant labels, the system automatically creates an order confirmation and updates the inventory in real time. The same process is applied during picking and shipping. The system bot monitors the entire process according to the algorithm shown in Table 2, thus minimizing logistical errors..

Table 2. A fragment of the Bot's initialization code and the Bot's operation diagram

Python code snippet	**Bot operation diagram**

```
...
try:
  # Finding ID from QR code
  match = re.search(r'#ID\$(\d+)',
qr_code_data)
  if match and match.group(1) == "001":
  logging.info(f" correct initialization
code recognized
 :{qr_code_data}"
   self.session_id=f"INTELOGBOT
   {datetime.now().
   strftime('%Y%m%d%H%M%S')}"
      self.is_active = True
      self.last_scan_time = time.time()
      # Platform notification about bot
initialization
      response =
self._send_api_request("bot/initialize",
{
      "session_id": self.session_id,
      "bot_type": "INTELOGBOT",
      "initialized_by": qr_code_data,
      "initialization_time":
datetime.now().isoformat()
                })
...
```





Source: own work

3. Intelligent system for identification and registration of deliveries

In the area of identification and registration of deliveries, the IPABOT system (BOT Intelligent Automation Process) has been implemented, which is initiated when scanning the QR code at the supplier, similarly to the case of component deliveries via the appropriate tag in the QR code (e.g.: #ID$001). The IPABOT bot operates on similar principles to INTELOGBOT, but uses advanced artificial intelligence algorithms to identify form fields in the HTML code and automatically enter data.

This system uses supervised machine learning mechanisms to map the information contained in the QR code to the appropriate fields of electronic forms [25]. The learning process is carried out by manual data entry by the operator and subsequent analysis of the modified HTML code.

5. Results and discussion

The conducted research has shown that the integration of the JSON format with the QR code standard, compliant with the GS1 Digital Link specification in version 1.2, has allowed the development of a comprehensive identification system with a high degree of universality. The solution facilitates the integration of IT systems and automates process flows in the supply chain.

Other outcomes of this concept include:

1. The implementation of the system enables the supplier to precisely identify all

assortment items of the order (taking into account the text description and photo visualization), automatically generate identification labels for individual items and documents, as well as update the status of the delivery (e.g. "confirmed", "in progress", "completed") in accordance with the industry standard ISO/IEC 15416:2016 [14].

2. In the delivery identification and registration system, this innovative methodology enables the system to create associations between fields. In this case, it was about fields concerning the name of the form field and the corresponding information, which is encoded in the QR code. Such action results in a reduction of the operator's workload and minimization of the risk of errors when entering data.

The implemented identification system enables cooperation partners to efficiently integrate various IT systems (e.g., ERP, WMS, MES) and automate logistics processes. This lowers operating costs and reduces errors. The INTELOG platform ensures transparency in the order process, precise product range identification, and automated logistics. This has enabled the realization of the benefits shown in Table 3.

Table 3. Summary of the project implementation effects

Lp.	[AP] Area/Process	[TA] Task/Activity	Before implementation		After implementation	
			[AT] Average time [sec]	[EF] Efficiency [%]	[AT] Average time [sec]	[EF] Efficiency [%]
1	Component delivery	Identification of inventory indexes	**26**	**15%**	**5**	**91%**
2		Identification of storage locations	**18**	**22%**	**4**	**94%**
3	Completion of the assembly order	Identification of inventory indexes	**19**	**16%**	**5**	**93%**
4		Identification of storage locations	**12**	**25%**	**4**	**95%**
5		Correction of errors (rework) in the order	**198**	**10%**	**15**	**87%**
6	Order picking	Identification of inventory indexes	**24**	**12%**	**5**	**93%**
7		Identification of storage locations	**16**	**18%**	**4**	**95%**
8		Labeling of order items	**135**	**7%**	**14**	**89%**

The implementation of a consistent identification system enabled:

1. Reduction of operating costs by 23% (~67,856.00 PLN/month).
2. Increased efficiency in the component warehouse – reduction of disassembly time by 28% (~16,594.00 PLN/month).
3. Reduction of the number of incidents of non-conformity during assembly by 87% (~28,767.00 PLN/month).
4. Increased efficiency in the order completion process by 16% (~19,729.00 PLN/month).
5. Shortening the delivery approval time by 35%.

To sum up, the implemented concept brought measurable and significant benefits in all indicated functional areas of logistics processes. The presented data emphasize the improvement of process efficiency. In the first one, related to components, the efficiency of warehouse index identification increased from 15% to 91%. In terms of storage locations, from 22% to 94%, while the time required to perform these operations has been shortened by 81% and 78%, respectively. The assembly order picking process has also seen improvements. The time required to identify storage locations has been reduced by around 75%. Of particular note is the reduction in the time required to correct errors in orders - from 198 to just 15 seconds (a 92% reduction), with an increase in efficiency from 10% to 87%.

The implementation of a consistent identification system has translated into concrete financial and operational benefits. A 23% reduction in operating costs (approximately 67 856 pln per month) is the result of the synergy of all the improvements introduced as part of the project. Also impressive is the 87% reduction in the number of non-conformity incidents at assembly, which translates into savings of around 28,767 pln per month. Increases in the efficiency of logistics processes, including a 28% reduction in decompletion times and a 16%

increase in order picking efficiency, have resulted in further savings totalling more than PLN 36 000 pln per month.

6. Summary

The research project developed an advanced system for the identification and automation of logistics processes. It was based on the JSON data format, which enables effective system integration through platform independence, high efficiency, and easy readability. The combination of JSON with the QR code standard created a versatile identification system that supports seamless integration with various IT systems, such as ERP, WMS, and MES, as well as the automation of logistics processes along the entire supply chain.

The most advanced element of the project is an intelligent system for identification and registration of deliveries using the IPABOT bot. This innovative solution uses artificial intelligence and machine learning algorithms to identify form fields in the HTML code and automatic data entry.

The limitations of the research are its scalability and implementation context. Since the research was conducted in a specific environment, in a specific company, which may limit the possibility of generalizing the results to other industries or companies with a different scale of operation. Therefore, in the future, the authors want to extend the research to various industries and logistics environments. In addition, it is also worth raising issues on the assessment of the risk associated with digital data exchange.

References

1. Basaldúa, M.S., Cruz Di Palma, R.J.: Production, Supply, Logistics, and Distribution. Springer Handbooks, Vol. part F674, 893-907 (2023), 10.1007/978-3-030-96729-1_40
2. Bedi, P., Das, S., Goyal, S.B., Rajawat, A.S., Kautish, S.: Revolutionizing sustainability: the role of robotics in supply chains. Computational Intelligence Techniques for Sustainable Supply Chain Management, 225-273 (2024), 10.1016/B978-0-443-18464-2.00007-8
3. Bertoni, N.: Material tracking system from billets to wire rods. Iron and Steel Technology, Vol. 14, Issue 8, 114-119, (2017)
4. Caballero-Gil, C., Molina-Gil, J., Caballero-Gil, P., Quesada-Arencibia, A.: IoT application in the supply chain logistics. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics, Vol. 8112 LNCS, Issue part 2, 55-62 (2013), 10.1007/978-3-642-53862-9_8
5. Chatterjee, S.K., Saha, S., Khalid, Z., Saha, H.N., Paul, P., Karlose, R.: Space effective and encrypted QR code with sender authorized security levels. 2018 IEEE 8th Annual Computing and Communication Workshop and Conference, CCWC 2018, Vol. 2018, 439-443, 10.1109/CCWC.2018.8301640
6. Chua, K.H., Rana, M.E., Hameed, V.A., Rana, M.H.: Crosschecking Verification Over Over the Ethereum Blockchain Using QR Scannable Products. 5th International Conference on Data Analytics for Business and Industry, ICDABI 2024, 190-199, 10.1109/ICDABI63787.2024.10800043
7. Di, Yi-J., Shi, Jian-P., Mao, Guo-Y.: A QR code identification technology in package auto-sorting system. Modern Physics Letters B, Vol. 31, Issue 19-21, (2017), 10.1142/S0217984917400358
8. Dohare, A.K., Mahesh, C., Ratan, M.K., Kancharla, R., Saini, H., Upmanu, V.: A deep learning approach for medicine preparation machines with SVM and CNN integration. Blockchain and IoT Approaches for Secure Electronic Health Records (HER), 138-159, (2024)
9. Echelmeyer, W., Bonini, M., Rohde, M.: From manufacturing to logistics: Development of a kinematic for autonomous unloading of containers. Advanced Materials Research, Vol. 903, 245-251 (2014), 10.4028/www.scientific.net/AMR.903.245
10. Ecma International: The JSON Data Interchange Syntax. ECMA-404, 2nd Edition, December 2017.

11. Feger, A.L.R.: Improving internal supply chain collaboration by increasing information-processing capacity: The role of enterprise information systems. International Journal of Enterprise Information Systems, Vol. 7, Issue 4, 1-12 (2011), 10.4018/jeis.2011100101
12. Florkowska, A., Trojak, M., Celniak, W., Stanuch, M., Daniol, M., Skalski, A.: Metrological Analysis of HoloLens 2 for Visual Marker-Based Surgical Navigation. IEEE International Conference on Imaging Systems and Techniques, Proceedings, IST 2023, 10.1109/IST59124.2023.10355714
13. Harish, K.S., Kotehal, P., Sandesh, M.M., Reddy, Y.M., Roopa, K., Lokesh, G.R.: Artificial Intelligence in Supply Chain Management: Trends and Implications. Nanotechnology Perceptions, Vol. 20, Issue S7, 1113-1120 (2024), 10.62441/nano-ntp.v20iS7.91
14. ISO/IEC 15416:2016 – Information technology – automatic identification and data capture techniques – Bar code print quality test specification – Linear symbols, International Organization for Standardization, (2016)
15. Kart, F., Moser, L.E., Melliar-Smith, P.M.: An automated supply Chain management system and its performance evaluation. International Journal of Information Systems and Supply Chain Management, Vol. 3, Issue 2, 84-107 (2010), 10.4018/jisscm.2010040105
16. Kikuchi, R., Yoshikawa, S., Jayaraman, P.K., Zheng, J., Maekawa, T.: Embedding QR codes onto B-spline surfaces for 3D printing. CAD Computer Aided Design, Vol. 102, 215 - 223, (2018)
17. Lakshmi, G.V., Gogulamudi, S., Nagaeswari, B., Reehana, S.: Blockchain Based Inventory Management by QR Code Using Open CV. International Conference on Computer Communication and Informatics, ICCCI 2021, 10.1109/ICCCI50826.2021.9402666
18. Lee, S.-J., Tewolde, G., Lim, J., Kwon, J.: QR-code based Localization for Indoor Mobile Robot with validation using a 3D optical tracking instrument. IEEE/ASME International Conference on Advanced Intelligent Mechatronics, AIM, Vol. 2015-August, 965-970, (2015)
19. Liu, L., Guo, W., Yang, Y., Guo, H.: Research on QR code logistics privacy based on segmented encryption and time-limited control. Chinese Journal of Network and Information Security, Vol. 5, Issue 4, 63-70, (2019), 10.11959/j.issn.2096-109x.2019039
20. Liu, Y., Yang, J., Liu, M.: Recognition of QR Code with mobile phones. Chinese Control and Decision Conference, 203-206, (2008)
21. Majdalawieh, M.: Building Trust in Supply Chains: The Blockchain-QR Code Advantage. Proceedings of IEEE/ACS International Conference on Computer Systems and Apllications, AICCSA (2023), 10.1109/AICCSA59173.2023.10479331
22. Negoita, R.F., Borangiu, T.: An online robotic process automation learning platform. eLearning and Software for Education Conference, Vol. 2, 173-180, (2022)
23. Patil, K., Ingawale, P., Suryavanshi, O., Kanekar, P., Trivedi, M.: TrackTrust: Revolutionizing Supply Chain Management Through Blockchain Integration. 2nd International Conference on Self Sustainable Artificial Intelligence Systems, ICSSAS 2024 – Proceedings, 1226-1231 (2024), 10.1109/ICSSAS64001.2024.10760294
24. Schaudt, L., Schlegel, D.: Combining Robotic Process Automation with Artificial Intelligence: Applications, Terminology, Benefits, and Challenges. Eurasian Studies in Business and Economics, Vol. 25, 83-99, (2023)
25. Smith, R., Johnson, B.: Supervised Learning Algorithms in Logistics Process Automation. International Journal of Artificial Intelligence Applications, 13(2), 78-92, (2022)
26. Thamilvanan, G., Mohanasundaram, K.: Quick response code as a communication medium. International Journal of Innovative Technology and Exploring Engineering, Vol. 8, Issue 10, 4190-4192 (2019)
27. Vajgel, B., Correa, P.L.P., Tossoli De Sousa, T., Encinas Quille, R.V., Bedoya, J.A.R., Almeida, G.M. De, Filgueiras, L.V.L., Demuner, V.R.S., Mollica, D.: Development of Intelligent Robotic Process Automation: A Utility Case Study in Brazil. IEEE Access, Vol. 9, 71222-71235, (2021)
28. Zaki, M.H., Mazen, S.A., Helal, I.M.A.: Robotic Process Automation in Software Testing: Challenges and Open Research Directions. Lecture Notes in Networks and Systems, Vol. 1283 LNNS, 197-207, (2025)