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Reviewing the Role of Machine Learning and IoT in ERP

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Abstract: The integration of Machine Learning (ML) and the Internet of Things (IoT) into ERP systems has significantly transformed business process optimization and management. ML algorithms enhance ERP capabilities by automating repetitive tasks, offering predictive insights, and enhancing decision-making processes. However, it is important to note that industrial operations and supply chain management are just a couple of the numerous operational domains that might gain advantages from the collection and monitoring of real-time data facilitated by Internet of Things devices. The synergy between IoT devices and organizations allows for the utilization of large amounts of data, leading to more accurate forecasting, improved resource allocation, and proactive maintenance measures. The incorporation of machine learning and the IoT into ERP systems enhances efficiency and competitiveness by optimizing firm operations and establishing a more flexible organizational framework. The integration of these technologies will be essential in redefining outdated ERP paradigms as they evolve, with the goal of promoting more intelligent and data-driven companies.

Keywords: Machine Learning, Internet of Things (IoT), Enterprise Resource Planning (ERP), Predictive Analytics, Real-time Data Collection

1. Introduction

Machine Learning (ML) and the Internet of Things (IoT) are transforming enterprise resource planning (ERP) systems, and organizations are utilizing these technologies to improve operational efficiency and decision-making in today's fast-paced business environment. ERP systems have historically provided a unified framework for a number of corporate processes, including accounting, HR, and supply chain management [1]. But new capabilities are introduced when ML and IoT are integrated, and these systems are greatly improved. Machine learning allows for the discovery of patterns and insights in massive data sets, which in turn allows for predictive analytics to guide strategic decisions and maximize the use of available resources. At the same time, Internet of Things devices offer up-to-the-minute information gathered from sensors and linked machinery, which enhances the data that ERP systems have access to and enables more accurate tracking, prediction, and preventative upkeep. When used in tandem, these technologies allow businesses to respond faster to shifting consumer preferences and industry trends, leading to a more data-driven and nimble style of management. In this review paper, we'll take a look at the present state of ERP systems, the possible advantages of ML and IoT, and the trends that could emerge in the future.

1.1 Background

Organizations' demands for better resource management and process simplification have driven the development of Enterprise Resource Planning (ERP) systems [2]. Traditional enterprise resource planning (ERP) systems frequently encountered problems with data silos and an absence of real-time insights, despite their initial design to combine fundamental activities like finance, inventories, and human resources. More agile and adaptable solutions are in high demand due to the rise of digital transformation. Machine learning (ML) is a game-changing technology that can analyze data more effectively than ever before [3]. This allows for better user experiences, automated decisions, and predictive analytics. Organizations may improve customer service, optimize inventory, and estimate demand with the help of ML algorithms, which allows for more informed strategic planning. Concurrently, the IoT has completely changed the way data is collected by enabling real-time communication between devices and sensors, which in turn generates useful information about the physical world. With this flood of up-to-the-minute information, ERP systems are able to enhance supply chain transparency, equipment tracking, and preventative maintenance. Businesses may improve operational efficiency and stay ahead of the competition by integrating ML and IoT into ERP systems. This not only overcomes the constraints of traditional approaches but also gives them the power to use data-driven insights.

1.2 Machine Learning

An area of AI known as Machine Learning (ML) allows computers to automatically learn new tasks, recognize patterns in data, and make judgments with little to no human input [4]. Machine learning (ML) sorts through mountains of data using algorithms and statistical models to find patterns that might improve decision-making, automation, and predictive analytics. Natural language processing, picture recognition, financial forecasting, and healthcare diagnostics are just a few of the many areas where ML has found use [5]. With the ever-increasing abundance of data, ML technologies are playing a pivotal role for companies looking to gain a competitive edge, streamline processes, and provide customers with personalized experiences. Innovative solutions to challenging challenges in today's data-driven landscape are being made possible by the constant progress of ML approaches, which include supervised, unsupervised, and reinforcement learning.

1.3 Internet of Things

A network of networked devices that can gather, share, and analyze data in real-time through communication and data exchange over the internet is called the Internet of Things (IoT) [6]. Various gadgets, ranging from commonplace wearables and smart thermostats to sensors for infrastructure and heavy industrial gear, make up this ecosystem. Organizations may improve operational efficiency, acquire important insights into user behavior and system performance, and optimize resource management by adopting IoT technologies [7]. Smart cities, healthcare, agriculture, and supply chain management are just a few of the many industries that can benefit from the automation and predictive maintenance made possible by the Internet of Things. In a world where connection and data processing capabilities are constantly improving, the Internet of Things (IoT) is poised to revolutionize sectors, encourage innovation, and give rise to new business models [8].

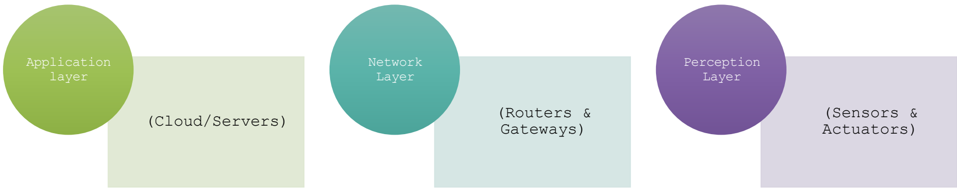

Fig 1 Layers in IOT devices

1.4 Enterprise Resource Planning

A unified platform for the integration and management of an organization's fundamental business activities is known as enterprise resource planning (ERP) [9]. By combining data from diverse areas like as finance, human resources, manufacturing, supply chain, and sales, ERP systems provide a holistic view of operations, boosting visibility and collaboration. Key to operational efficiency is the ability to access data in real-time, simplify procedures, and make better decisions thanks to this integration. ERP systems are adaptable and can be tailored to suit the unique requirements of various businesses [10,11]. They offer a range of capabilities, such as CRM, inventory management, and project management. Enterprise resource planning (ERP) systems are getting smarter and more flexible by incorporating cutting-edge tech like cloud computing, AI, and the internet of things (IoT) as more and more companies embrace digital transformation plans.

Fig 2 Importance of Enterprise Resource Planning [16]

1.5 Machine Learning and IoT in ERP

Enterprise Resource Planning (ERP) solutions that incorporate Machine Learning (ML) and the Internet of Things (IoT) are revolutionizing the way businesses oversee operations and make choices based on data [12]. In order to improve supply chain management, optimize inventory levels, and predict demand, ML algorithms sift through massive datasets produced by IoT devices. One example is the ability to gain insights into equipment performance through real-time data from connected sensors [13]. This data allows for preventive maintenance and reduces downtime. Thanks to this complementary relationship, ERP systems can do more than just do routine tasks; they can also promote more intelligent automation and better decision-making. Companies may increase their operational efficiency, allocate resources more wisely, and react swiftly to changes in the market by using real-time information and advanced analytics [14]. Customer relationships are fortified and revenue is increased through the capacity to tailor customer experiences according to predicted analytics. In the future of corporate management, these technologies will be integral to ERP systems, allowing firms to adapt faster and stay competitive in a dynamic market [15].

1.6 Significance of research

Research is important because it can propel innovation in many different areas, increase our understanding of the world, and help with decision-making. Research uncovers evidence-based insights that can enhance methods and solutions by methodically probing topics and exploring new ideas. When it comes to integrating technologies like ML and the IoT into systems like ERP, research is essential for finding effective implementation strategies, identifying potential challenges, and evaluating how it will affect organizational efficiency. Academics and businesses work together more closely through research, which speeds up technological progress by facilitating the exchange of knowledge and resources. In the end, firms may use the results of this type of research to make better decisions, improve operational performance, and remain competitive in the ever-changing digital market.

1.7 Motivation of research

The growing importance of data in decision-making and operational efficiency has prompted studies on how to incorporate the Internet of Things (IoT) and Machine Learning (ML) into ERP systems. It is becoming more and more important for enterprises to learn how to use these new technologies in order to optimize their processes and acquire a competitive edge. Problems like ineffective resource management and sluggish reactions to changes in the market motivate researchers to seek for novel solutions. Furthermore, in order for firms to adapt and succeed, there is a pressing need to investigate the consequences of these technological breakthroughs for current business processes. Improved business outcomes and customer satisfaction can be achieved by studying the synergies between ML, IoT, and ERP. This research aims to deliver significant insights that can lead to corporate systems that are more agile, responsive, and intelligent.

2. Literature review

C. V. G. Mendoza et al. (2020) [1] presented evolutionary optimization of ensemble learning to detect sentiment polarity in an imbalanced multiclass dataset. This paper suggests using Differential Evolution to estimate an optimal weighting method for multiclass classification and imbalanced corpora. With the suggested optimum weighting technique, the ensemble beats past research on this issue without NLP approaches, improving classification scores on the entire TASS challenge test set (General corpus).

When J Bzai et al. (2022) introduced machine learning to the Internet of Things (IoT), they presented a data study, applications, and industrial perspectives [2]. They review ML-enabled IoT literature from data, applications, and industries. We examine how ML and IoT work together to make our surroundings smarter by evaluating over 300 sources. We examine many novel methods and their applications. IoT discussions now encompass the Internet of Behavior (IoB), lightweight deep learning, edge and fog computing, linked autonomous vehicles, pandemic management, and the Internet of Things. They also describe IoT challenges as technological, individual, corporate, or social. This paper outlines how to maximize benefits and minimize hazards from the Internet of Things to help our communities thrive.

J. R. Jian et al. (2020) compared large-scale evolutionary optimization experimentally [3]. This article compares multiple LSEO algorithms using benchmark functions to determine their strengths and drawbacks. We assess seven prominent LSEO algorithms using CEC2010 and CEC2013 large-scale optimization benchmark functions. Next, use simulation data to identify which algorithms perform best on benchmark functions. We conclude with several LSEO algorithm research directions.

Junior et al. (2020) [4] Enhanced Evolutionary Method for Automated ML Classifier Ensembles: improved algorithm and results. A modified version of our Evolutionary Algorithm (EA), an Estimation of Distribution Algorithm, automates the process of selecting the appropriate classifier ensemble and hyperparameter settings for an input dataset in Auto-ML. The new EA was compared against its predecessor, a random forest method, and an Auto-ML form of Auto-WEKA that searched the same classifier ensembles. We tested the proposed EA against the powerful ensemble algorithm random forest. In testing using 21 datasets, the improved EA version surpassed all other approaches in error rate, precision, recall, and F-measure.

Logeswaran K et al. discussed improving evolutionary algorithms for transactional database pattern mining using machine learning. (2019) In recent years, data analysts have struggled to mine high utility itemset (HUI) from a transactional database using typical methods. Utility mining algorithms struggle with the growing search space and calculating a database's minimum utility threshold. Using evolutionary techniques to extract the HUI from the transactional database can solve these issues. But testing each optimization problem's supporting functions individually is inefficient and increases the algorithm's temporal complexity. A reinforcement learning-based technique can improve the algorithm's efficiency by automatically choosing the best fitness function while it runs. The optimization method also dynamically selects the optimal function when multiple functions are capable.

The 2020 study by M. Shams et al. [6] A natural evolution optimization-based deep learning system for neurological disease classification. The proposed classifier combines cutting-edge EEG categorization methods as part of a signal processing chain. Before obtaining spectral or statistical data, the EEG signal is wavelet-transformed into numerous subbands. We look into artificial bee colony qualities to select the best. Finally, the recommended NEDL classifier processes the selected characteristics. Next, the approach is tested on motor imaging and epilepsy benchmark datasets. The recommended strategy outperforms existing and competing deep learning models in several trials.

Madjid Tavana studied IoT ERP [7]. The author evaluated issues, open questions, answers, architectural elements, and future research. This study explores the design, installation, use, and problems of an IoT-based ERP system. We do this by examining and analyzing IoT research to highlight its distinctive features and examine its possible effects on enterprise resource planning.

S. A. Bkheet et al. (2021) [8] examined IoT authentication strategies.Sensor networks have created the Internet of Things (IoT), a technological breakthrough. It has garnered attention since it affects many aspects of our lives. IoT envisions a future where any inanimate thing with a unique identification can connect to the network and share data with any other object worldwide. Data communication networks help the Internet of Things acquire, process, and distribute data. Since the beginning of Internet of Things (IoT) development, RFID, barcodes/2D codes, IP addresses, EPCs, and others have been used for item identification. To maintain its growth, the Internet of Things (IoT) sector needs a better way to identify the huge diversity of Internet-connected gadgets. In recent years, computer vision, fingerprinting, and machine learning have underpinned several cutting-edge approaches. This article introduces IOT and its core components, emphasizing on IOT identification, since it is considered the foundation of IOT systems.

S. A. N. Alexandropoulos et al. (2019) introduced Machine Learning Multi-Objective Evolutionary Optimization Algorithms [9]. Multi-objective evolutionary optimization helps machine learning algorithms maximize hyper-parameters and identify the best model when they have competing performance goals. This paper reviews new multi-objective evolutionary algorithms for data preparation, classification, clustering, and association rules at the four main data mining and machine learning tasks.

S. Q. Salih et al. (2020) created the best AI model for submerged weir scouring depth [10]. PSO optimizes the SVR model's internal hyperparameters and predictors' "feature selection" for??? modeling. Interconnected geometrical parameters, flow data, and sediment characteristics form the prediction matrix. Our model is validated by comparing it to many widely used machine learning models in the literature. Prediction was excellent using the tBPSO-SVR model. Quantitatively, tBPSO-SVR had the best coefficient of determination and least mean absolute error. Despite having fewer input parameters, the hybrid AI model predicted depth scouring well.

T. Ghosh et al. (2020) [11] optimized multi-response machining using evolutionary algorithms and machine learning. The general data-driven technique could assist any production process. We examine many literature cases to ensure the recommended process works. Our limitations show that the data-driven NSGA-III outperforms the Multi-Objective Evolutionary Algorithm based on Decomposition (MOEA/D). Statistical study shows both techniques perform effectively. The findings could improve machining conditions and performance. The surrogate-assisted NSGA III and multi-response manufacturing process optimization technique are novel components of this research.

Machine learning for IoT security was the focus of A. Sagu et al. (2020) [12]. The Internet of Things (IoT) is increasingly integrating the digital and physical worlds, improving life. More than 20 billion objects will be linked by 2024. It's a double-edged sword with potential and risks. Security of billions of devices and networks is a major concern. IoT safety poses many challenges, which this article examined. It also considered machine learning solutions. Besides discussing the methodologies, factors, and aspects of the several procedures, the study asks if one is better.

A. Sagu et al. (2020) evaluated IoT security [13]. Because the IoT ecosystem is so pervasive, most consumers don't know how to safeguard their devices or want to. Machine learning can improve IoT security. Recent studies show that researchers are using machine learning to secure IoT devices. This research compiled a complete literature evaluation on machine learning IoT device security.

For Cognitive Radio network spectrum allocation, Amandeep Kaur et al. (2020) [14] investigated an evolutionary multi-objective optimization system based on Reinforcement Learning. The spectrum allocation conundrum with competing network capacity and spectrum efficiency is solved by modeling the circumstance as a multi-objective optimization problem in CR networks. We describe an enhanced Reinforcement Learning-based Non-dominated Sorting Genetic Algorithm that blends evolutionary methods and machine learning. NSGA—RL handles competing objectives with self-tuning parameters. The numerical results show that the suggested approach works well with the Pareto optimum set and yields the optimal spectrum allocation solution for CR networks.

A. J. Barker et al. (2020) created quantum gas using machine learning optimization [15]. This paper presents differential evolution, non-parametric Gaussian process regression, and an artificial neural network-based gradient-based function approximator. The learner can build a BEC from random starting settings using online optimization without prior apparatus knowledge. When cooling operations are optimized, BECatoms rise by four times compared to manual settings. This automated approach keeps performance near-optimal after a long run. We also show that machine learning can discover the system's main instability reasons.

Table 1 Literature Survey

Ref	Author / Year	Objective	Technique	Limitation
1	C. V. García-Mendoza et al. (2020)	Determine sentiment polarity in an unbalanced multiclass corpus	Ensemble Learning Optimization	Limited to unbalanced datasets
2	J. Bzai et al. (2022)	Explore data, applications, and industry perspectives of ML-enabled IoT	Literature Review	General overview; lacks specific case studies
3	J. R. Jian et al. (2020)	Survey and compare large-scale evolutionary optimization methods	Comparative Study	Focused on theoretical approaches

4	J. C. Xavier-Júnior et al. (2020)	Develop an improved algorithm for automated machine learning focusing on classifier ensembles	Evolutionary Algorithm	May require extensive computation time
5	Logeswaran K. et al. (2019)	Optimize evolutionary algorithms for pattern mining in transactional databases	Machine Learning Techniques	Limited to specific database types
6	M. Shams, A. Sagheer (2020)	Classify neurological disorders using deep learning	Natural Evolution Optimization	Data dependency; may not generalize across conditions
7	Madjid Tavana (2020)	Address challenges and future directions of IoT-based ERP systems	Review of Literature	Lacks empirical validation
8	S. A. Bkheet, J. I. Agbinya (2021)	Review identity methods for IoT	Literature Review	Broad scope; may lack depth in specific areas
9	S. A. N. Alexandropoulos et al. (2019)	Survey multi-objective evolutionary optimization algorithms for machine learning	Survey	May overlook practical applications
10	S. Q. Salih et al. (2020)	Model scouring depth of submerged weirs using evolutionary optimization	Artificial Intelligence Model	May be site-specific
11	T. Ghosh, K. Martinsen (2020)	Optimize multi-response machining processes using ML and evolutionary algorithms	Machine Learning, Evolutionary Algorithms	Complexity in implementation
12	A. Sagu*, N. S. Gill (2020)	Secure IoT environments using machine learning techniques	Machine Learning Techniques	Potentially high resource consumption
13	A. Sagu, N. S. Gill (2020)	Enhance security in IoT environments through ML	Machine Learning Techniques	Requires extensive data for training
14	A. Kaur, K. Kumar (2020)	Optimize spectrum allocation in Cognitive Radio networks using reinforcement learning	Reinforcement Learning	May face scalability issues
15	A. J. Barker et al. (2020)	Apply ML optimization methods in the production of a quantum gas	Machine Learning Optimization	Limited applicability to quantum systems

3. Problem Statement

Traditional research did just a small amount of work on ERP systems in Internet of Things environments. In addition, there was a lack of accuracy and performance in the setting that was considered traditional. As a result, the proposed research has concentrated on improving the accuracy of ERP administration in an Internet of Things context without sacrificing efficiency.

4. Research Methodology

There have been research on ERP management that have looked at the Internet of Things (IoT) and machine learning. After that, we looked at the issues that came up because of these studies. Accuracy and performance issues are a problem for researchers in this area. Next, a learning model that is both efficient and effective would be created using compression and edge detection. At last, we check how well and accurately the proposed model worked. How applications use machine learning and the internet of things has been the subject of several research. The results were analyzed at last. Present research in this area falls short of expectations in terms of both performance and accuracy. How successfully a business adapts to the various changes brought about by ERP has a direct correlation to its capacity to maintain customer satisfaction. Customer service and general company management might be drastically altered by internet-connected smart devices that give companies data on product quality, shipping, and other metrics. As an alternative, a new area called cloud ERP that uses the internet of things (IoT) has emerged, which claims to provide better administration and customer services.

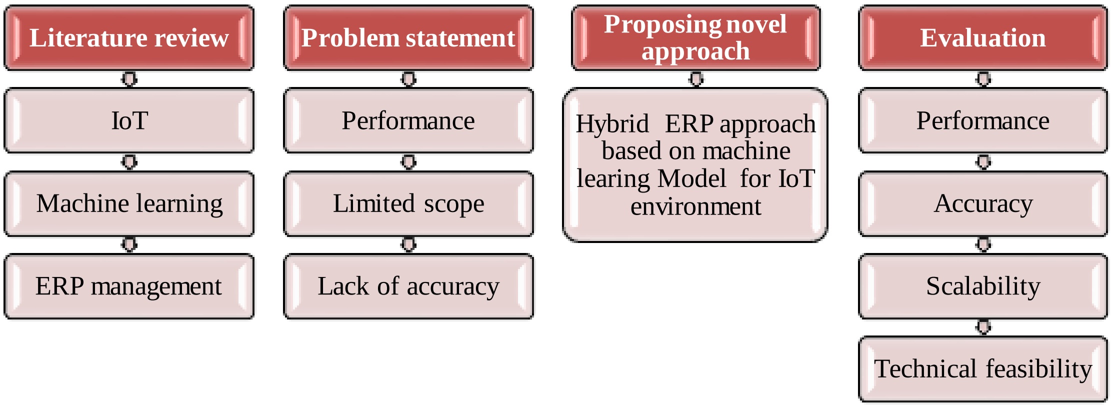

Fig 3 Research Methodology

5. Need of Research

In today's lightning-fast corporate world, research into the integration of IoT and Machine Learning (ML) into ERP systems is absolutely essential. In order to stay competitive and efficient, more and more organizations are embracing digital technology. It is crucial to grasp the real-world uses and consequences of these advancements. Research is useful for finding the best practices, comparing different integration methodologies, and finding obstacles to implementation. In addition, new trends and changing market demands necessitate constant inquiry due to the fast development of technology. Organizations may optimize operations, enhance customer engagement, and leverage data-driven decision-making with the help of research that explores the intersections of ML, IoT, and ERP. Research like this has a multiplicative effect: it helps individual companies succeed, but it also adds to our collective knowledge and encourages progress in all kinds of fields.

6. Future scope

Machine learning (ML) and the internet of things (IoT) integration with ERP systems has a huge and bright future. Better ERP systems will be available in the future thanks to increased capacity for data analytics, predictive modeling, and real-time decision-making made possible by ever-improving technology. Organizations will gain deeper insights into operational performance and customer behavior thanks to the extraordinary volume of data generated by the increasingly prevalent IoT devices. In order to make ML models within ERP frameworks more accurate and efficient, future research might center on creating more complex algorithms. Opportunities to investigate how ML and IoT may maximize resource utilization and decrease waste will also arise as sustainability becomes an increasingly important focus for organizations. New types of subscription-based services or pricing based on results might emerge as a result of the confluence of these technologies. In general, a new age of agility, efficiency, and competitive advantage will be ushered in by the integration of ML and IoT into ERP systems, which is expected to radically alter the way businesses function.

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