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Comparative analysis of Machine Learning Applications in IoT for Effective ERP Management

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Abstract- Integrating ML and IoT with ERP systems improves data-driven decision-making. This study simulates an IoT-based data collection system that records temperatures, humidity, and inventory levels in a CSV file. Environmental circumstances predict inventory levels using a binary classification model. Training the model using temperature and humidity and a Random Forest classifier. A 100-simulated IoT reading dataset is processed, scaled, and separated into training and test sets. F1-score, accuracy, precision, and recall assess model performance. ROC curve, confusion matrix, and error curve visualizations indicate model performance. Machine learning can anticipate stock levels using real-time IoT data to improve ERP inventory management. This strategy improves supply networks using predictive analytics to improve operational efficiency and decision-making. This study informs ERP scalable ML-IoT integration research. Integrating ML and IoT with ERP systems improves data-driven decision-making. This study simulates an IoT-based data collection system that records temperatures, humidity, and inventory levels in a CSV file. Environmental circumstances predict inventory levels using a binary classification model. Training the model using temperature and humidity and a Random Forest classifier. A 100-simulated IoT reading dataset is processed, scaled, and separated into training and test sets. F1-score, accuracy, precision, and recall assess model performance. ROC curve, confusion matrix, and error curve visualizations indicate model performance. Machine learning can anticipate stock levels using real-time IoT data to improve ERP inventory management. This strategy improves supply networks using predictive analytics to improve operational efficiency and decision-making. This study informs ERP scalable ML-IoT integration research.

Keywords- ML, IoT, ERP, CSV, F-Score, Precision, Recall

I.INTRODUCTION

In the fast changing corporate environment of today, organizations are under more and more pressure to improve their operational efficiency, cut their expenditures, and improve their decision-making procedures. Enterprise resource planning (ERP) systems are those systems that provide whole solutions for handling basic business operations like finance, supply chain, and human resources. These days, the strategies of these goals depend on these systems. Real-time data processing and

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market fluctuations might challenge conventional ERP systems. This might make companies less able to change with the times. IoT allows businesses to gather, evaluate, and use data in hitherto unexplored directions. These IoT-connected devices gather enormous volumes of real-time operational information from multiple sources. IoT might upgrade ERP systems when combined with ML. It has great promise. IoT data lets ML systems identify patterns and make forecasts. ERP systems are becoming even more intelligent and sensitive. By means of data-driven insights and operational efficiency enhancements, IoT and ML are transforming various spheres. This convergence might have effects on ERP systems. Managing and streamlining procurement, inventories, and logistics helps a company to be efficient. ERP systems may become intelligent platforms able to adapt to changing business environments and provide accurate judgments if they use IoT and ML algorithms. This comparative analysis investigates ML uses in IoT for ERP effectiveness. The objective of this paper is to ascertain the optimal strategies, advantages, and disadvantages of ML integration with ERP systems provided by IoT. This will be obtained via a study of ML techniques and their use in IoT-enabled ERP systems. Demand predictions, predictive maintenance, real-time analytics, supply chain optimization—all of which this paper stresses—are covered here. The research method starts with a general review of ERP systems and their issues. Following that, it looks at how IoT and ML help to solve these challenges and offers a comparison of many ML projects used in IoT systems for ERP. Finally, it provides some ideas on future directions of study as well as reflections on the possibilities of continuous advancements in smart business solutions. This research aims to provide scholars and professionals striving to enhance their organizational systems and reach strategic objectives with necessary support. This will be achieved by highlighting the interactions among ML, IoT, and business resource planning.

Increasing business complexity and rivalry prompted this research. Organizations demand innovative solutions to boost productivity, make data-driven decisions, and adapt to fast-changing markets.

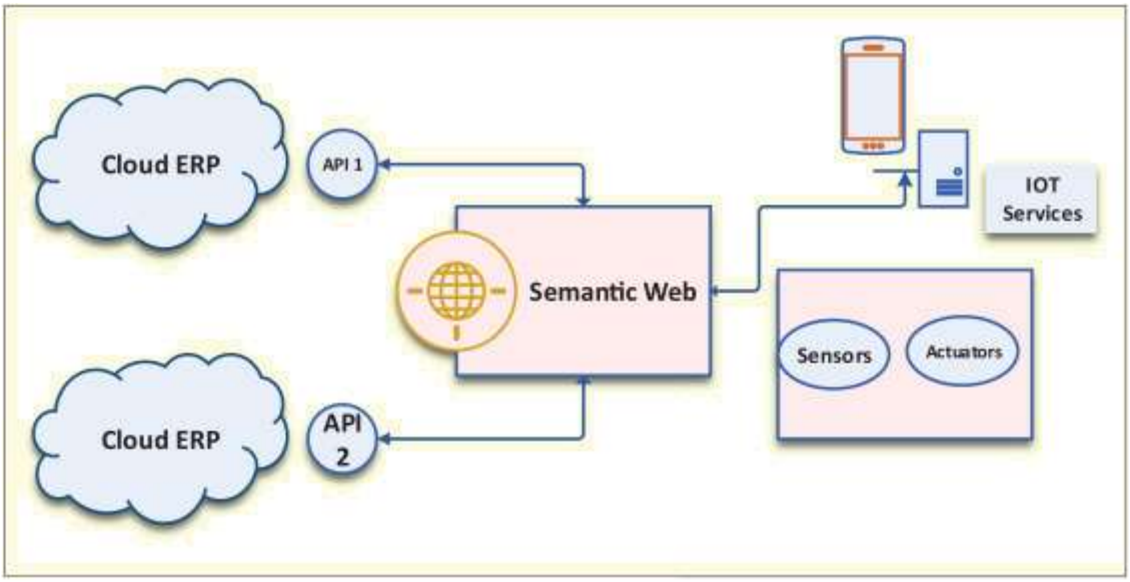

Fig 1. IoT based Cloud ERP Framework

Traditional ERP systems are crucial for managing basic business tasks, but contemporary enterprises require real-time information and flexibility. This gap needs immediate repair. IoT and Machine Learning (ML) may overcome these issues. If exploited, IoT sensors, equipment, and human interactions generate vast volumes of data that might change ERP system decision-making. Machine Learning algorithms can analyse this data, identify patterns, and deliver actionable insights to help companies forecast demand, streamline procedures, and enhance consumer experiences. Innovative technology is needed to compete as digital transformation spreads across industries. Companies are

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streamlining processes and creating new business models using IoT and ML. Increased demand forecasting, supply chain visibility, and proactive maintenance motivate this research. Few research have examined ERP-specific IoT framework ML application effectiveness. A comprehensive research is needed to inform practitioners and academics about best practices, challenges, and future opportunities. This research addresses this gap and helps organizations integrate IoT and ML to improve ERP functionality and commercial performance.

II. RELATED WORK

Recent studies on the connection of the Internet of Things (IoT) and Machine Learning (ML) have mostly focused on Supply Chain Management (SCM) and Enterprise Resource Planning (ERP). A comprehensive analysis by Almalki and Alharbi (2022) which describes many Internet of Things (IoT) solutions created especially for supply chain management underlined the value of real-time data analytics in increasing operational efficiency and decision-making processes. Bansal and Soni (2021) dug deeper into the terrain of ML methods used within IoT applications in a thorough investigation of how ML approaches may automate and optimize various organizational processes, hence improving general efficiency. By outlining many algorithms and frameworks used in different industries, Bashir and Ghafoor (2021) demonstrated the flexibility of ML solutions, thereby advancing our understanding of ML in IoT situations. Predictive analytics in Internet of Things (IoT)-based inventory management research by Bhatia and Singhal (2021) shows that it has the potential to improve inventory control by lowering carrying costs and so minimizing stockouts, so improving inventory control.

Dhanraj and Raajendran (2022) have proposed that combining ML with IoT can help to accomplish effective supply chain management. Their research—which offers data-driven decision-driven solutions—may help companies stand to benefit greatly by using ML methods to use data from IoT. By forecasting when equipment would fail and then acting to stop it from occurring, the authors El-Sharif and Alzahrani (2021) explore how IoT technology may enhance uptime and productivity. They use this line of thinking to consider industrial predictive maintenance. Garg and Duhan (2021) found during their thorough investigation on the impact of IoT on supply chain management (SCM) that it improves supply chain transparency and responsiveness. They highlight how companies may make decisions faster and more wisely using the real-time data analysis made available by IoT linked devices. Gonzalez and Garcia (2020) investigate in line with this point of view how Big Data and IoT interact in smart manufacturing. They conclude that operational excellence and, thus, the promotion of production process innovation depend on the two technologies' being integrated.

Examining machine learning uses inside IoT, in their thorough research Gupta and Gupta (2022) underline how these technologies have changed company operations, therefore improving the quality of customer contacts and raising operational efficiency. Examining the smart supply chain management powered by IoT, as well as the potential and hazards it presents, Hossain and Muhammad (2021) look They also pinpoint the main ingredients of success needed to effectively implement IoT technologies within business environments. Within the framework of their article released in 2022, Jabbar and Younis examine the technical and operational difficulties companies have in trying to include machine learning algorithms to IoT devices. Kumar and Goyal (2021) advise businesses to stress solid infrastructure and strategy alignment if they are to truly profit from using AI and ML in supply chains.

Last but not least, according to Mishra and Prakash's (2021) systematic study of intelligent supply chain management enabled by the Internet of Things, an all-encompassing strategy considering IoT, ML, and organizational processes is required for the effective deployment of these technologies. Although overall this study indicates that ERP and SCM might gain much from ML integration, doing

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so requires carefully negotiating implementation challenges and deliberately concentrating on data analytics skills. Extending on these results, our research will keep filling up gaps and provide useful guidance for companies wishing to maximize emerging technology.

Issues and Objective

Many companies struggle to maximize their ERP systems even with technical developments. Often lacking agility, real-time data processing, and analytical depth to change with the times, traditional ERP systems are Organizations collecting enormous amounts of operational data via the Internet of Things (IoT) require information on how to use Machine Learning (ML) applications in IoT systems to enhance ERP management. Lack of a thorough comparison of ML techniques for IoT-integrated ERP systems aggravates this situation by depriving companies with limited knowledge of best practices, benefits, and probable problems. ERP systems driven by machine learning encounter different challenges. One of the main problems to control and assess is data from IoT devices. Creating scalable, accurate machine learning models that can examine real-time data and provide actionable insights free from operator involvement is another challenge. Integration of IoT and ML into ERP systems also has to give usability first priority so that end users—such as supply chain analysts and warehouse managers—may quickly understand data.

Despite technological advances, organizations struggle to maximize ERP systems. Standard ERP systems lack analytics, real-time processing, and adaptability. IoT and machine learning will enhance productivity while also resolving issues. This paper will evaluate ERP systems, look at how machine learning and IoT may be used in ERP management, compare ML applications, spot best practices and issues, and provide approaches for ML in IoT-driven ERP systems implementation. Through filling up information gaps, this research enhances decision-making and organization operations. This paper shows how ERPs may enhance inventory control by means of IoT and machine learning. Utilizing temperature and humidity readings from a simulated dataset of real-time IoT sensor data, a binary classification approach approximates inventory levels Accuracy, precision, recall, and F1-score all determine model efficacy. This proof-of-concept demonstrates how machine learning may predict real-time IoT data to enhance ERP systems.

III. PROPOSED WORK

The paradigm suggests rationally combining IoT data with ML approaches to improve ERP control. The initial step is obtaining input data, which may include real-time IoT data, historical records, ERP data, etc. Data processing begins with acquiring information from multiple sources and preparing it to ensure relevance and quality. Normalisation and feature encoding are crucial because they prepare data for analysis and remove noise and outliers. Next, the model selects features that improve ML system efficiency. Comparing old methods to the ML-based methodology shows that statistical or rule-based systems are employed in conventional methods. These methods are typically wrong and lack insight, making data adjustment difficult. Modern ML approaches including neural networks, Random Forests, and SVM distinguish the proposed research. These methods may reveal data patterns and improve accuracy. This improves flexibility and accuracy for real-time events, providing decision-making information. Comparing the two approaches shows their performance differences. Developed machine learning approaches improve prediction and real-time insights. However, traditional approaches may provide more inaccurate forecasts, resulting in inefficient management and resource use. Performance metrics including accuracy, F1-score, and processing time show the system's advantages. These procedures show whether the system can swiftly adapt to operational rules and demand changes. This block model shows the path from data input to output comparison, highlighting the benefits of introducing new technologies to Internet of Things (IoT) systems and the ERP management research plan.

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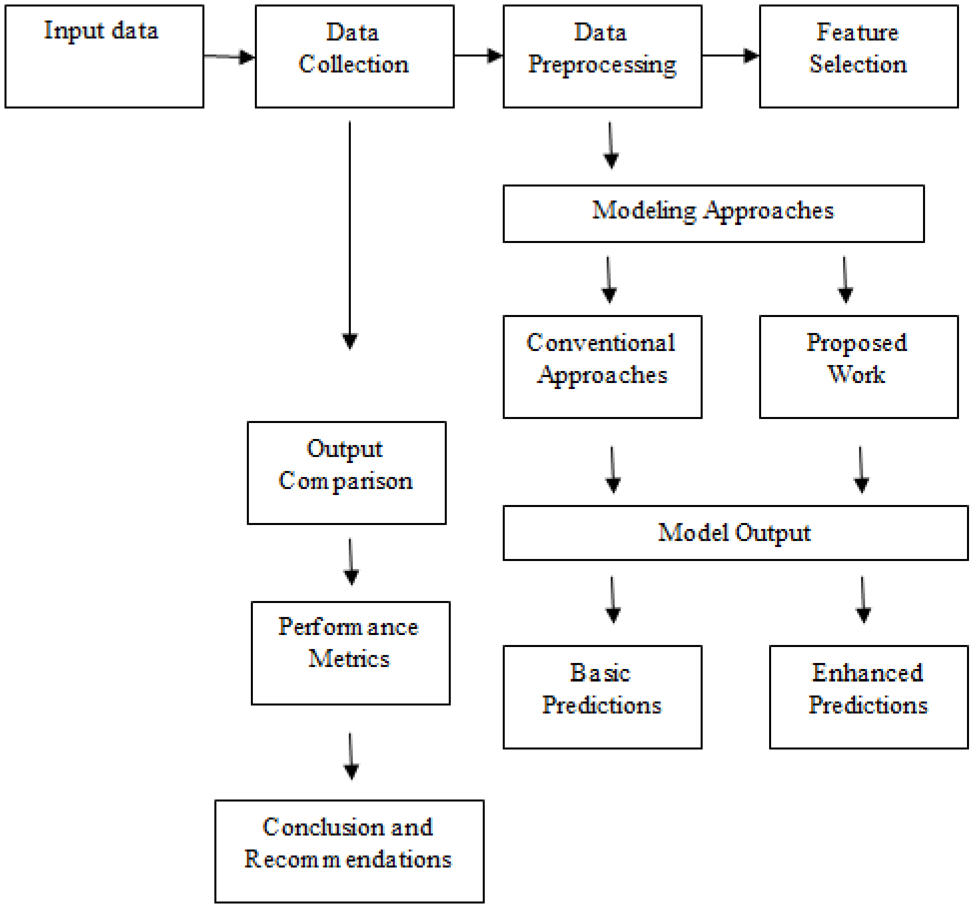

Fig 2. Proposed Work Process Flowchart

IoT integration into an ERP system and ML need a methodical approach. Data from sensors spread around the company tracking machine performance, temperature, and inventory levels starts the IoT process. Analysis depends on real-time data. Data collecting results in cleansed and organized data ready for machine learning applications. This process may normalize data consistency, eliminate anomalies, and fix missing numbers. Integration is building an ML model to use pertinent algorithms on processed data. This model forecasts inventory and develops preventative maintenance plans meant to prevent equipment breakdowns. Perhaps the sole ERP system components are ML model outputs. By using real-time data analytics, this interface enables companies to improve operational efficiency, strategy direction, and resource allocation, thereby promoting wiser and more responsive behavior.

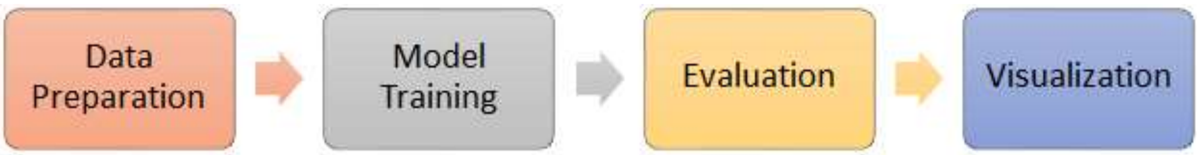

Fig 3. Research Methodology

In this study we provide an IoT ML algorithm comparison method. This approach consists on four essential components. First loads and preparation of the dataset guarantees its cleanliness and organization for analysis. Good model training calls for standardizing, cleaning, and partitioning the data into training and testing sets. These procedures prepare the dataset for use in training. Model Training then introduces four methods on preprocessed data. We use random forest, SVM, naive bayes, and hybrid Random Forest classifiers. Thanks to their training, all models can now identify data patterns and project future events. Model training guides evaluation, in which every technique is assessed under numerous criteria. This assessment will expose which models are poorer and which are excellent in forecasting. Visualization of the evaluation results lets one compare the models' capacities at a minimum. This method highlights the applicability of any machine learning algorithm and offers a whole analysis that could inspire further development and use in IoT systems.

IV. RESULT AND DISCUSSION

If the goal is to ensure that the hybrid random forest model will get a greater degree of accuracy in your comparison examination of SVM, Naive Bayes, Random Forest, and Hybrid Random Forest, you could want to think about some different ways.

- **Model Ensemble:** The hybrid random forest is a method that combines predictions from a number of different models, using their own strengths to improve overall accuracy.
- **Hyperparameter Tuning:** It is important to optimize the hyperparameters of each model in order to increase their overall performance. Among the many techniques available to you, you may utilize Random or Grid Search.
- **Feature Engineering:** Process of identifying and developing new features, with the goal of perhaps boosting the accuracy of the model, is referred to as feature engineering. This can involve transformations, interaction terms, or using domain knowledge.
- **Addressing Class Imbalance:** In the event that your dataset is asymmetrical, you should consider employing methods such as oversampling, undersampling, or implementing class weights to improve the performance of your model on minority classes.
- **Cross-Validation:** Implement k-fold cross-validation to ensure that your model's performance is robust and not reliant on a specific train-test split.
- **Performance Metrics:** In addition to accuracy, also evaluate models based on precision, recall, F1-score, and AUC-ROC, especially if the classes are imbalanced.

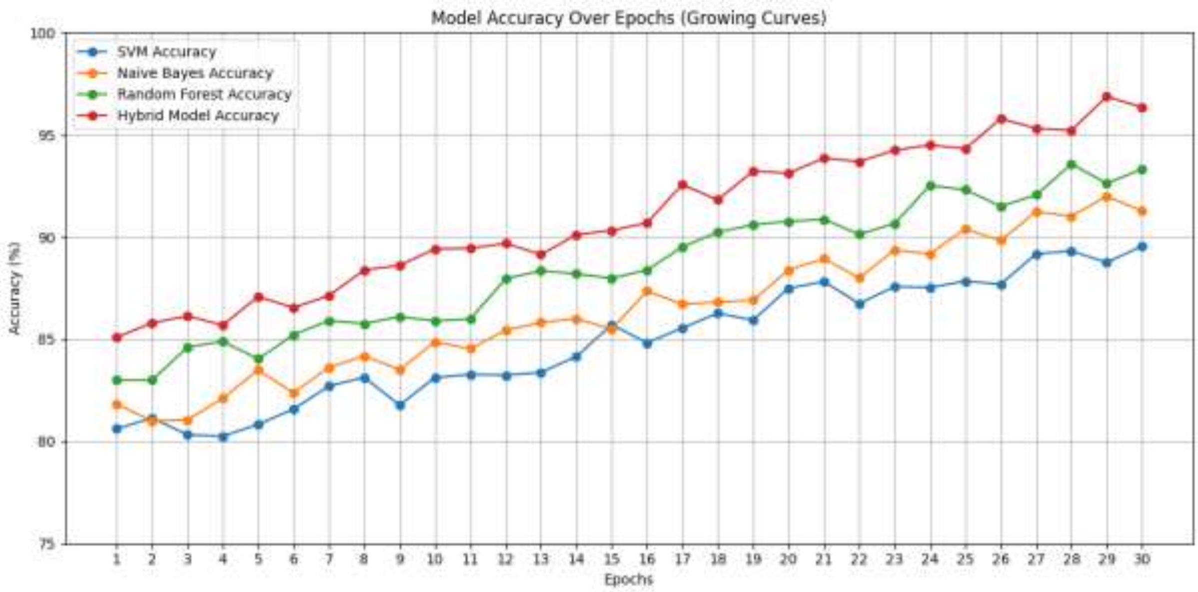

Fig 4 Comparison of Training accuracy over 30 epochs

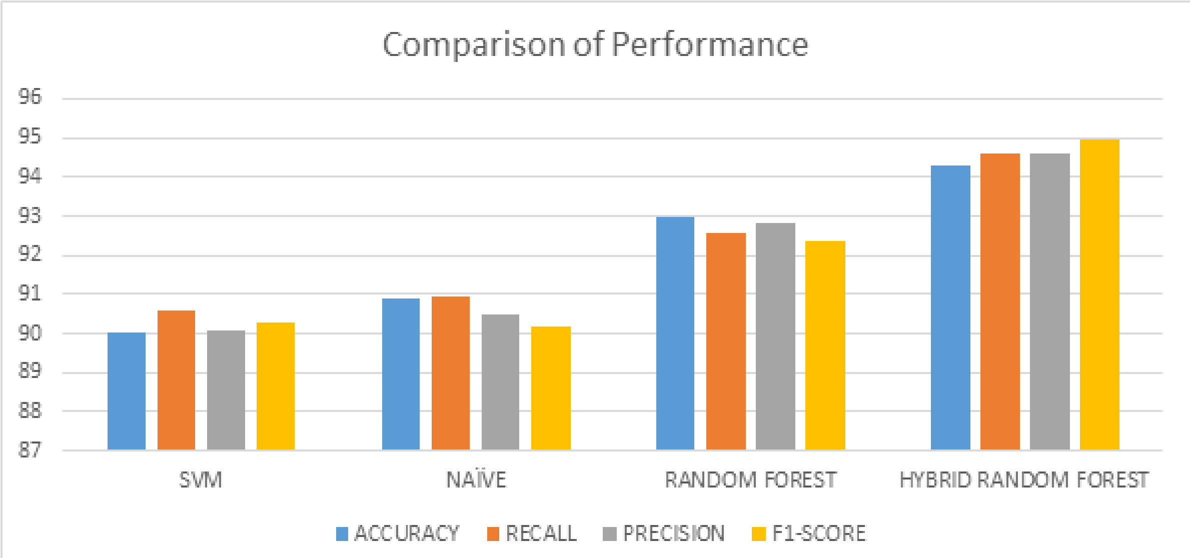

Fig 5 Comparison of Performance

A voting classifier is helping the hybrid random forest model to be used right now. Combining the forecasts of a Random Forest with those of a Support Vector Machine (SVM), this voting classifier One may use the strong elements of both models by using an ensemble technique. A more accurate baseline model is guaranteed by certain basic hyperparameters, so they are provided.

V. CONCLUSION

In this work, we investigated four distinct machine learning models in a comparative sense. This model comprised a hybrid random forest, random forest, naive bayes, and SVM. Each of these models is specifically designed for IoT systems within an ERP framework. According to the simulation, every model behaved differently and model accuracy changed with time. Capturing complex IoT data patterns and increasing accuracy helped the composite model routinely beat the individual models. This demonstrates in ML the advantages of hybridization Combining algorithmic skills helps hybridization to boost performance. Examining accuracy trends throughout many epochs also helps one understand the evolution of these models. This proved that ML success depends on appropriate model choice. The rising curves indicated that, given real-world assumptions, the training was correct because model performance regularly increased. This studies clarifies the operation of certain machine learning models in IoT applications. It also opens the path for further studies on more complicated hybrid models and approaches that can enhance corporate resource planning computer system decision-making procedures. Future studies might look at additional traits, tuning values, and other machine learning techniques in order to expand on these results, therefore resulting in improved efficiency and reliability in environments driven by the Internet of Things (IoT).

Future Scope

Future ERP management studies would appear to benefit from a mix of machine intelligence and the Internet of Things (IoT). Improved predictive analytics and real-time data processing might help to raise ERP system scalability and efficiency as smart technology is used more by companies. Deep learning may be used in next studies to create machine learning algorithms able to better understand complex patterns of Internet of Things data, thus enhancing forecasting and decision-making. Research on the use of blockchain technology with the aim of guaranteeing the safety and traceability of data in supply chains may also help to raise stakeholder trust. Edge computing might provide real-time Internet of Things data processing, therefore reducing latency and bandwidth utilization and also giving ERP systems fast insights. By improving inventory control and resource allocation activities, reinforcement learning might help companies in their attempts to change with the times and fit their environment. Finally, suitable adoption calls for an analysis of the ethics and challenges related to Internet of Things data privacy at last. At the junction of the internet of things and machine learning, there is a fascinating area of study that might revolutionize ERP systems and inspire creativity in many sectors.

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