Automated Inventory Tracking and Alert System

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Abstract

The research is on inventory management systems, focusing on IoT-based solutions, RFID technology, and machine learning applications. The study examines various systems, including automated inventory tracking, real-time monitoring, and predictive analytics for demand forecasting. The survey highlights the benefits of these systems, such as improved inventory accuracy, reduced stockouts, and enhanced customer satisfaction. However, it also discusses challenges and limitations, including dependency on network connectivity, initial setup costs, and data accuracy concerns. This survey provides a comprehensive overview of the current state of inventory management systems, identifying opportunities for future research and development.

Keywords: IoT, Cloud Infrastructure, Machine Learning, Streaming, Network, Deep Learning.

1. Introduction

An automated inventory management system is a technology that helps companies monitor their stock levels automatically with minimal human intervention. It is a proactive approach that enables companies avoid stockouts, excess inventory, missed sales, and unsatisfied customers The technology prevents overstocking and guarantees that products are available when needed by effectively monitoring and controlling stock levels. By satisfying demand without excess or shortfall, this optimization lowers the chance of stockouts, increases

sales possibilities, and improves customer satisfaction. Figure.1 depicts the automated inventory management.

Figure 1. Automated Inventory Management [16]

The benefits of automating inventory management include improved efficiency, better decision-making, and increased customer satisfaction, along with enhanced accuracy, reduced cost, and complete visibility of the stock levels. The automated inventory management enables businesses to monitor and handle multiple warehouses and update the stock levels automatically with the help of barcode scanners. Set reorder points and notification alerts to avoid the stockouts and facilitate timely restocking respectively. The Figure 2 depicts the benefits of automated inventory management.

Figure 2. Benefits of Automated Inventory Management

It also helps in easily integrating with other platforms, such as accounting tools, CRM software, E-commerce platforms, and shipping providers, and managing the entire business in a single platform [17].

The Internet of Things plays a major role in automating the process of inventory management by enabling real-time tracking and monitoring, which helps in ensure that stock is always available. Additionally, the use of machine learning or the deep learning can provide

the organizations with deeper insights about the customer behaviour and the demand patterns, enabling a more accurate inventory forecast and stock levels adjustments.

1.1 Principles of Automated Inventory Management

The Automated Inventory Management System consists of several important principles, with its core being totally compliant actually through monitoring inventory levels, movements, and updates, which are automatically done by RFID/barcode scan. All of this information is housed in a centralized database located in the cloud that can easily be accessed and managed. Finally, the alerting system automatically generates notifications for low stock, expiring items, and other emergencies.

To avoid all forms of human error, the system ensures more accuracy and efficiency through automated gathering and updating of data. Thus, it involves a mobile/web application that would allow a user to access inventory information without any fuss to assist him/her in making an appropriate decision. The system includes the use of RFID, barcode scanners, a cloud-based database, automated alert systems, mobile/web applications, and data analytics as its components. Automated Inventory Management System, with these principles and components together, provide a number of benefits. They include the improved accuracy, increased efficiency, improved visibility, improved decision-making, and scalability. Automated inventory management processes will save the company time and resource requirements, to optimize level of inventory and enhance efficiency in a supply chain. The Figure .3 illustrates the general diagram of automated inventory management through IoT.
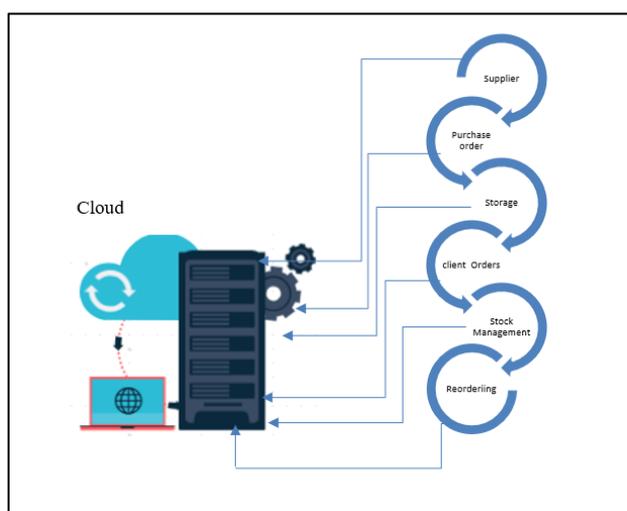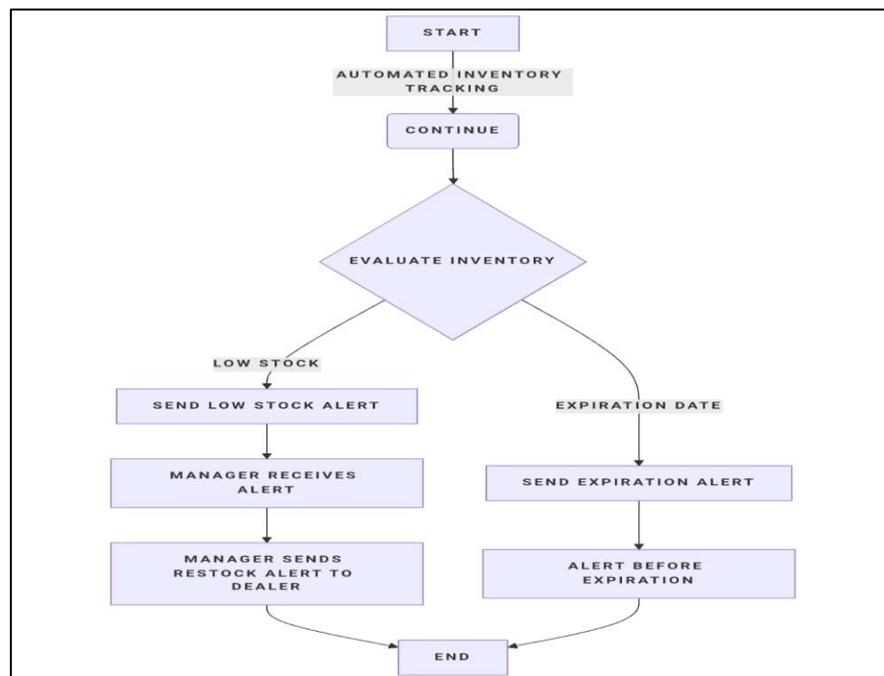

Figure 3. Automated Inventory Management through IoT

The study focuses on IoT-based solutions, RFID technology, and the applications of machine learning in automated inventory management and provides a comprehensive overview of the current state of inventory management systems, identifying opportunities for future research and development.

1.2 Flow chart

The Automated Inventory Tracking flowchart in Figure 4 illustrates a streamlined process that begins with continuous monitoring of inventory levels and expiration dates. The process then evaluates the inventory to identify low stock or nearing expiration dates, triggering alerts to be sent to the manager. Upon receiving these alerts, the manager takes action and sends restock requests to dealers, ensuring that inventory levels are replenished and expiring products are addressed in a timely manner. Ultimately, the flowchart outlines an efficient and automated process for managing inventory, minimizing the risk of stockouts and expired products.

Figure 4. Automated Inventory Management Flowchart

2. Literature Survey

Ananthi et al. [1]developed an IoT-based inventory control system aimed at reducing the inefficiencies of manual inventory management. Using RFID technology, the system provides real-time tracking of products, with the collected data being stored on an IoT platform

for easy remote access. The system operates with minimal human intervention, offering a cost-effective solution for managing large warehouses. A Raspberry Pi controller facilitates data management, ensuring that inventory tracking is dynamic and continuously updated. This approach improves operational efficiency by automating the tracking of products, leading to more accurate and timely stock monitoring.

Hasan et al. [2] extended the application of IoT to warehouse management, emphasizing automation to improve efficiency. Their system integrates RFID technology with a web-based interface, built using PHP and MySQL, to streamline the tracking of items in a warehouse. The automated system minimizes human error and data loss, which are common in manual tracking systems. By reducing labor costs and improving data accuracy, this system is particularly effective in large-scale warehouse operations, where manual inventory methods often fall short.

Sheth et al. [3] introduced a system that leverages data analytics and machine learning to enhance inventory management. Their solution records and stores data on stock levels, sales trends, and product performance, allowing organizations to generate detailed reports for better decision- making. By utilizing machine learning algorithms such as regression modeling and market basket analysis, the system identifies high-demand products, helping businesses optimize stock levels and reduce inefficiencies in their inventory processes.

Jyothi and Navya et al. [4] developed a smart store management system to address common issues such as stock shortages in retail environments. Their system continuously monitors stock levels in real-time and alerts store managers when items need to be restocked. This automation eliminates the need for manual stock tracking, reducing the likelihood of "out-of-stock" situations, which can lead to customer dissatisfaction and lost sales. The system's ability to provide real-time data ensures that retail outlets can maintain adequate stock levels at all times.

Irawan et al. [5] designed a web-based stock monitoring system aimed at small retail stores. The system simplifies inventory management by allowing store owners to track stock levels and financial transactions in real-time. Built using PHP, JavaScript, and MySQL, the system offers an efficient, low-cost solution for monitoring stock, reducing the discrepancies often caused by manual record-keeping. This technology helps small businesses improve their operational efficiency by streamlining inventory management.

Khanna and Tomar [6] proposed an IoT-based interactive shopping ecosystem that integrates cloud computing with inventory management. Their system uses Wireless Sensor Networks (WSNs) to provide real-time monitoring of products, enabling store owners to track product performance and sales trends more effectively. The system also leverages cloud technology to handle the large volumes of data generated by IoT devices, making it scalable and suitable for environments with diverse product lines. This approach enables businesses to better manage their inventory and make data-driven decisions.

Xin Yue et al.[7] developed a stock management system using Microsoft Access and Visual Basic (VB) to manage inventory for small businesses. The system provides an efficient solution for managing raw materials, tracking stock, and handling user and password management. By using Microsoft Access as the database, the system ensures data uniformity, integrity, and security. This approach allows small businesses to implement cost-effective stock management systems that are easy to use and maintain without requiring extensive technical expertise. The system's simplicity and low cost make it suitable for small-scale operations that need to manage inventory with minimal resources.

Zong et al. [8] explored the integration of Enterprise Resource Planning (ERP) principles with inventory management systems. Focusing on the aviation industry, their system automates stock management processes, improving accuracy and efficiency. By incorporating advanced algorithms and ERP methodologies, the system enables businesses to manage complex inventory operations with greater precision, ultimately optimizing stock management and reducing operational costs.

Kaushik and Dahiya [9] addressed the growing concern over security and privacy in IoT-based inventory systems, particularly in retail and e-business. As these systems become more widely adopted, they are increasingly vulnerable to cyber-attacks. Their study emphasizes the need for robust security frameworks to protect sensitive business data and ensure the reliability of IoT-based systems. Effective security measures, such as encryption and secure communication protocols, are essential for safeguarding inventory data in these digital systems.

Majdi et al. [10] explored the use of computer vision in managing supermarket stock. By using deep learning models, the system can monitor product availability on shelves and detect when items are running low or misplaced. This system provides real-time alerts to store staff, ensuring that products are restocked on time. The use of computer vision helps improve

shelf management and ensures that customers can always find the products they need, thereby enhancing the overall shopping experience.

Lee and Farahmand et al [11] explored the interaction between inventory management and logistics strategies in a supply chain context. Using a simulation-based approach, their system integrates inventory tracking with transportation management to minimize overall costs. By optimizing demand volumes and shipping sizes, the system improves supply chain efficiency, demonstrating how inventory and logistics can be modeled together to achieve cost savings.

Wen and Qin et al [12] developed a decision support system (DSS) for stock trading, which shares commonalities with inventory management systems in terms of data-driven decision-making. The system uses a set of rules and strategies to assess financial conditions and analyze stock market uncertainties. Although focused on stock trading, the system highlights how predictive models and data analysis can help optimize decisions—parallels that can be drawn with inventory management processes. By applying similar decision-support techniques, businesses can manage their stock with reduced risk and increased efficiency, using predictive insights to forecast demand and optimize stock levels.

Mishra and Mohapatro et al [13] developed an IoT-cloud architecture for real-time inventory tracking using RFID tags. The system applies machine learning algorithms, such as Support Vector Machines (SVM) and K-Nearest Neighbors (KNN), to predict stock requirements based on historical data. By providing real-time tracking and predictive insights, the system helps businesses optimize stock levels, reducing the risk of shortages and overstocking. This approach enhances the overall efficiency of inventory management by making data-driven predictions about future stock needs.

Managing inventory and safety stock is essential for efficient production, especially when demand for materials is unpredictable. In their study, Todor Stoilov and Krasimira Stoilova et al [14] created a model to optimize inventory and safety stock levels by considering both supply management and reserve stock. This model helps businesses prepare for unexpected changes in material availability, which is critical in industries like livestock feed production where the ingredients might fluctuate. Skill-based Course Recommendation System.

Supermarket billing systems have undergone significant advancements, aiming to improve efficiency, reduce customer wait times, and enhance overall shopping experiences. Traditionally, supermarkets have used barcode systems for billing, but newer technologies like Radio Frequency Identification (RFID) have shown great potential in streamlining this process. RFID uses radio waves to automatically detect and track items, making the scanning process faster and reducing errors. In their research, Naik et al. [15] integrates a webcam-based billing system with RFID technology to further enhance the efficiency of supermarket billing.

3. Comparative Study

Table 1. Comparative Study

Ref. No.	Author Name	Publication Year and Publisher	Title of Paper	Methodology	Advantage	Disadvantage
1.	K. Ananthi R. Rajavel S. Sabarikannan A. Srisaran C. Sridhar,	IEEE 2021	Design and Fabrication of IoT based inventory control system	The system employs IoT and RFID technology to track inventory in real- time. RFID tags attached to items transmit data to a receiver, which is connected to a Raspberry Pi controller. The data is uploaded to a web platform for real-time monitoring and analysis, accessible remotely via the internet.	Real-time inventory tracking Low-cost and minimal human intervention Suitable for large warehouses	Dependent on reliable internet connectivity Limited by the accuracy of RFID tags and sensors
2.	M. K. Hasan M. Junjie A. K. M. Ahasan Habib A. Al Mamun T. M. Ghazal R. A. Saeed	IEEE 2022	IoT-Based Warehouse Management System	The system integrates RFID technology with a web-based interface, using PHP and MySQL to automate inventory management. RFID tags are used to track items in real-time, with data stored in a MySQL database accessible via a web application.	Reduces manual labor and errors Improves efficiency by automating data collection and updates Cost-effective for large-scale operations	Initial setup cost may be high May require technical expertise to maintain the system

3.	R. Sheth M. Vora R. Sharma M. Thaker P. Bhavathankar	IEEE 2020	A Proficient Process for Systematic Inventory Management	This system leverages machine learning algorithms like regression modeling and market basket analysis to predict stock demand and optimize inventory levels. Data visualization tools are used to generate reports on sales and inventory trends, helping businesses manage stock levels effectively.	Data-driven insights for better decision-making Optimizes stock levels and reduces excess inventory Can predict product demand and improve profitability	Complex setup and requires expertise in data analysis May not be cost-effective for small businesses
4.	G. D. Jyothi K. Navya	IEEE 2017	Design and implementation of a store management system	The system monitors stock levels in real-time using RFID and sensors. It automates the process of tracking product availability and alerts store managers when restocking is needed.	Eliminates manual inventory tracking Reduces "out-of- stock" situations, improving customer satisfaction Cost-effective for retail environments	May not be scalable for very large operations Depends heavily on the accuracy of sensor data
5.	Irawan Michael Danny Albertus Dwiyoga Widiantoro Agus Cahyo Nugroho	IEEE 2022	Design Of Monitoring Information System Stock Items At Partner Stores In Web-Based Semarang	The system uses PHP, JavaScript, and MySQL to create a web-based interface for monitoring stock levels and transactions in real-time. The system helps reduce errors by automating inventory tracking.	Simple and cost-effective solution for small businesses Reduces manual errors in stock tracking Easy to implement and maintain	Limited scalability for large businesses Basic features may not be sufficient for more complex inventory needs
	Khanna	IEEE 2016	IoT based interactive	The system integrates IoT with cloud computing to provide real-time inventory management. Wireless Sensor Networks (WSNs) are used to monitor stock levels and sales trends, while	Real-time monitoring of stock and sales trends Scalable for large retail	Requires a reliable internet connection for cloud access

6.	R. Tomar			shopping ecosystem	the cloud handles data storage and processing.	environments Provides insights for optimizing inventory	Initial setup cost may be high for smaller businesses
7.	Xin Yue Haifeng Ma Jingfeng Song	IEEE 2010	Design of stock management system based on Microsoft Access	The system uses Microsoft Access and Visual Basic to manage raw material inventory. It tracks stock levels, manages user access, and handles password management. The system stores data securely and allows for the easy retrieval of stock information.	Simple to use and maintain Low-cost solution for small businesses Ensures data security and integrity	Limited scalability Not suitable for large or complex inventory systems
8.	S. Zong Y. Yu J. Shi	IEEE 2010	Stock management system based on principle of ERP and its algorithm design	The system integrates Enterprise Resource Planning (ERP) with inventory management processes. It uses advanced algorithms to optimize stock tracking and automate inventory processes in large enterprises, particularly in aviation.	Improves accuracy and efficiency in stock management Suitable for complex inventory operations Supports large-scale organizations	High implementation cost Requires specialized knowledge for maintenance and use
9.	K. Kaushik S. Dahiya	IEEE 2018	Security and Privacy in IoT based E-Business and Retail	The paper addresses security and privacy concerns in IoT-based inventory systems, particularly in retail environments. It discusses the importance of secure communication protocols and encryption to protect sensitive data.	Highlights critical security issues in IoT systems Provides a framework for securing inventory systems Essential for businesses using IoT solutions	Security solutions may add complexity to the system May increase implementation and operational costs
10.	M. A. Majdi B. Sena Bayu Dewantara	IEEE 2020	Product Stock Management Using Computer Vision	Utilizes a camera system and deep learning (tiny YOLOv3) to detect products on supermarket shelves, identifying when items	High accuracy in detecting stock levels Automates shelf monitoring, reducing manual labor	High initial setup cost Dependent on camera quality and lighting conditions

	M. M. Bachtíar			are low in stock or misplaced, and alerting staff for restocking.	Provides real-time alerts for efficient restocking	
11.	E. Lee K. Farahmand	IEEE 2010	Simulation of a base stock inventory management system integrated with transportation strategies of a logistic network	The system uses a simulation-based approach to integrate inventory management with logistics strategies. The simulation optimizes demand volumes and shipping sizes to reduce supply chain costs.	Reduces overall supply chain costs Optimizes logistics and inventory management together Provides accurate demand and shipping predictions	Complex setup requiring significant resources May be difficult to implement in small-scale operations

The summary in Table 1 highlights how IoT, RFID, and machine learning transform Inventory management by automating tracking, improving decision-making, and enabling real-time monitoring. These solutions reduce manual labor, enhance efficiency, and offer scalable options for diverse applications. However, challenges like high setup costs, dependency on network stability, and the need for accurate data and security measures must be addressed for Sustainable Implementation.

Among the many benefits offered by inventory management systems are data-driven decision-making, automation, and real-time tracking. IoT and RFID-based systems, such those developed by K. Ananthi [1] and M.K. Hasan [2] are perfect for large-scale operations because they increase efficiency by automating data collecting, decreasing manual intervention, and lowering mistakes. Advanced analytics are provided by machine learning-driven strategies [3], which estimate demand, optimize inventory, and cut down on surplus stock to increase profitability. Cost-effective systems that simplify inventory tracking, increase customer satisfaction and are especially well-suited for small firms and retail environments [4,5]. These methods do, however, have some significant drawbacks. As noted in [2]., they may require significant upfront setup expenditures and technical knowledge on how, and they frequently depend on dependable internet access and precise sensors, as observed in IoT-based solutions. While basic systems might not have the sophisticated functionality or scalability needed by larger companies, machine learning systems can be resource-intensive and complex, making

them less viable for smaller businesses. Because of these trade-offs, businesses must choose solutions that meet their needs in terms of scale, complexity, and money.

4. Future work

To address the disadvantages identified in the study, this research proposes a decision support system (DSS) for stock trading. The system integrates machine learning algorithms, real-time market data analysis, multi- criteria decision-making. The suggested method aims to overcome the existing limitations, such as dependence on data quality, complexity in rule development, limited adaptability to market changes, potential biases in expert rules, and high development and maintenance costs.

The research will utilize tools including programming languages (Python, Java), DSS softwar , financial data providers (Quandl, Yahoo Finance), expert system development tools (CLIPS, JESS), and data visualization tools (Tableau) are planned to be used in the research to develop web application for automated inventory management.

5. Conclusion

The Automated Inventory Tracking and Alert System represents a significant leap forward in inventory management. By utilizing barcode scanning, automated alerts, cloud-based databases, and user-friendly mobile/web applications, this innovative solution transforms inventory management into an efficient, accurate, and data-driven process. The system eradicates manual counting errors, provides real-time visibility, optimizes resource utilization, and ensures timely tracking of expiration dates and batch numbers. Its centralized management and accessibility empower businesses to make informed decisions, reduce costs, and enhance operational efficiency. Furthermore the study's comprehensive overview of the current state of inventory management systems has paved way for the future research on web application development. This includes integrating machine learning algorithms, real-time market data analysis, multi- criteria decision-making, with the aim of addressing the existing limitations, such as dependence on data quality, complexity in rule development, limited adaptability to market changes, potential biases in expert rules, and high development and maintenance costs. By addressing these challenges, future advancements aim to create systems that are more adaptable, efficient, and cost-effective, paving the way for streamlined operations and sustained business growth.

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