SMART INVENTORY MANAGEMENT SYSTEM USING MACHINE LEARNING

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***Abstract*—A successful inventory management is the key to matching the supply with the demand, though conventional systems rely on long manual recordings, which are not accurate and lead to monetary loss. This paper proposes a Smart Inventory Management System that carries prediction of the demand using historical sales data with the help of the Random Forest algorithm along with real-time stock monitoring using IoT sensors. The data processing and analysis through cloud infrastructure improve accuracy in stock, reduce manual intervention, and maximize costs through predictive analysis and automated restocking notifications. The Results show a 30% increase in accuracy to inventory with a 25% decrease in costs associated with these methods compared to the traditional ones. Future releases focus on integrating deep learning, blockchain technology for secure payment, and multi-warehouse support, showing the potential of AI-driven systems to redefine inventory management within modern-day enterprises.**

Keywords—Inventory management; Machine Learning; Supply chain; Demand forecasting.

I. INTRODUCTION

Inventory is the stock of raw materials, work-in-progress (partially finished goods), and finished goods that an organization keeps to satisfy its operational requirements. It is a significant investment and potentially a source of waste that needs to be managed well. Inventory is an IT system to keep records of all activities related to an inventory's distance, movement, and sales for future reference through predictive analysis. Effective inventory management does not allow for excessive stock but provides enough stock for the utilization of forecasted [1] demand. An ideal inventory control system ensures that the goods in the warehouse would keep the business running, but not too much stock that ties up their scarce cash resources. It is one of those activities where all business needs should be predicted. Most calls that are usually made are crisis calls, but those in charge of inventory should find alternatives without choking off cash on non-moving stock. One of the most important problems in every retail business is predicting product demand [2].

Another aspect to consider is how exactly we shall be utilizing artificial intelligence in inventory management. In other words, is it of any help in inventory management? Artificial intelligence should be working with human control, interfacing with one component of a larger system but never as a substitute for that system or the system itself. Still, quite a few companies are now looking at AI in the context of inventory, and it's working quite well for them, and this gives us hope that AI may actually land itself a real role in demand forecasting.

The shift from traditional inventory management principles stems from tremendous amounts of real-time data that are generated almost spontaneously on the Internet as well as in the networked environment of enterprise software systems and smart products. Managers will do well to learn how to utilize this newly available data to gain competitive advantage against other e-commerce companies by redesigning their inventories. Among others, Amazon, one of the titans of the industry, utilizes inventory management coupled with artificial intelligence to forecast almost everything perfectly. "Optimum inventory should be managed by all companies so that under-inventory can be eliminated, which disrupts the financial numbers. Only through better planning would an analysis of internal and external factors contribute to managing inventory in a better light for operational purposes. [3]."

II. LITERATURE SURVEY

Principle Of Inventory Management: The e-commerce industry is booming, and along with this comes few inevitable conditions that revolve around this sector's need for effective inventory management. It does create a gap, the area of further research on developing existing inventory management methodologies.

Currently, e-commerce leaders were fully using machine learning solution through probabilistic demand forecasting models-based end-to-end constructs such as Apache Spark. Operations normally involve processing enormous sets of data. Forecasting comprises two approaches generally: Time series approach and machine learning approaches.

Case study concerning inventory management focuses on identifying factors that affect inventory optimization for

small and medium enterprises (SMEs) in steel manufacturing industry. The research utilizes both structured and unstructured questionnaires for effective inventory management, comprising internal and external determinants.

Artificial Neural Networks (ANN), an intelligent system that employs layers of neurons, are indeed proficient at solving fitting problems. A backtracking analysis on the use of ANNin inventory management would bring a better prediction capability in its applications.

AI helps with customer information and buying behavior forecasting, production schedules based on demand, seasonal fluctuations, and notifying for inventory reorders [4].

Another method for effectively stock-keeping is Decision Support System (DSS) to ensure continued availability [5].

In order to facilitate inventory evaluation encompassing many attributes, a hybrid strategy combining different machine-learning approaches with multi-criteria decision-making methods is used. This method uses ABC analyses to determine class, with support vector machines (SVM), Bayesian networks, and artificial neural networks (ANN) helping to forecast different classes for inventory items [6].

Predictive modeling can also help in correcting for dead inventory by use of predictive algorithms that forecast part obsolescence ahead of time with reasonable accuracy [7].

ABCA analysis is a classification technique that assigns a particular class to each item, thus becoming a strong base for demand forecasting. It allows a fine-tuned classification for inventory stock [8].

Multi-despatching systems based on the JADE platform are agents that partake in natural transition from manual to automated inventory processes. The agents communicate through message-passing and help to facilitate the inventory management process. [10].

III. RELATED WORK

In the last few decades, the methodologies developed toward improvements in operational efficiency, demand forecasting, and supply chain management have brought the utmost advancements to studies of inventory management systems. These include numerous approaches, such as web-based solutions, predictive modeling, artificial intelligence (AI), and reinforcement learning (RL). The basic architecture of the system is shown in fig. 1.

A. Internet-Enabled Encrypted Inventory Systems

One major innovation in inventory management is setting up the text internet-enabled encrypted inventory system to enable

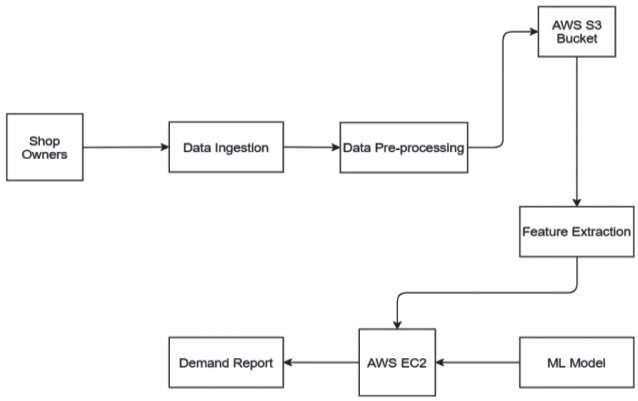

Fig. 1. Architecture

real-time stock monitoring and data integrity. We discussed adding encryption mechanisms for secure handling of data, which would be of utmost importance for organizations having multiple distribution facilities. The system runs on web-space and offers real-time tracking with increased transparency so that chances of inventory mismanagement are thwarted as much as possible.

B. Enterprise Resource Planning (ERP) Systems

ERP systems stand at the center of research in inventory management concerning **inventory optimization**. Yang et al. [11] proved that ERP systems align real-time information between mobile and central databases for dynamic inventory management. These systems optimize away any operational inefficiency and make themselves responsive to changing dmand, thus allowing firms to respond fast to market fluctuations.

Predictive Modeling for Demand Forecasting. The techniques of predictive modeling are turned effective for opti- mization of inventories especially demand predictions. Kusmana et al. [12] have developed an online inventory system employing machine learning algorithms like decision trees and linear regression to ensure effective demand forecasting. It minimizes the accumulation of excess inventory and reduces out-of-stocks, thus maximizing both turnover and efficiency of inventory.

Artificial Intelligence and Machine Learning: Their Use in Inventory Management In recent times, advances in the field of ML and AI have facilitated tremendous changes in the field of inventory management. Specific examples are the successful applications of **Support Vector Machines (SVM)** and **Artificial Neural Network (ANN)** methods for demand forecasting and automatic stock replenishment [13]. They use associated historical sales records to forecast future variances in demand in order to minimize waste by maintaining stock levels in times of changing market conditions.

C. Reinforcement Learning (RL) for Dynamic Inventory Control

Reinforcement Learning (RL) has emerged as one possible promising approach for dynamic inventory management systems. RL algorithms enable the system to learn the optimal inventory level over real-time feedback concerning sales, customer demand, and supplier lead times. Unlike classical forecasting, RL continuously learns to adjust for changing market conditions, making it ideally suited to uncertain and variable environments.

D. Internet of Things (IoT) in Inventory Management

Another possible area in stock management is the Internet of Things (IoT). Bensoussan et al. [14] pointed to sensor- based stock monitoring as an opportunity for diminishing inventory management costs. The IoT sensors pass information concerning real-time stock movement, product expiration, or warehouse health that contributes in enhancing the decision-making process and efficiency in terms of inventory regulation.

IV. MODEL TESTING

Six experiments using various predictive models were carried out by the authors during the model development stage. The models are displayed together with a description in the following table. A variety of assessment metrics, including MSE, MAE, MAPE, and RMSE, were employed in the thorough examination of the CNN-LSTM model's effectiveness in demand forecasting.

To comprehend the model's performance and generalisation, the 20,668-row data set was methodically divided into three separate sets: training, validation, and test. To train and optimise the model's parameters, the training set—which comprises the majority of the data—is utilised. The validation set was crucial in choosing the model and adjusting the hyperparameters. The test set was hidden from training, yet it gave a fair indication of how well the model could forecast performance using fresh, unidentified data. As a result, the divided data is shown in Table I:

TABLE I DATA SPLIT

Set	**Percentage**	**Sample Count**
Train	70%	14667
Test	15%	3101
Valid	15%	3100

In order to assess the performance of the various models and determine the best strategy for demand forecasting in the clothing supply chain, the evaluation metrics scores that were collected are shown in the Table II.

TABLE II
Testing Results

Index	Model Name	MAE	MAPE	MSE	RMSE
1	LSTM	62.16	28.50%	0.0227	154.15
2	BiLSTM	38.36	23.10%	0.0187	160.78
3	CNN-LSTM	42.97	24.68%	0.0085	89.22
4	ARIMA-LSTM	58.88	77.64%	0.0133	220.33
5	BPNN-LSTM	40.01	25.29%	0.0223	124.98
6	ARIMA-CNN-LSTM	64.51	26.40%	0.0636	129.39

V. CONCLUSION AND FUTURE WORK

There is a need of inventory management to avoid redundancy for efficient operation in a supply chain with a cost-saving and increase efficiency within business operations. In this paper, a Smart Inventory Management System has been proposed that combines intelligent learning, IoT-enabled track- ing, and cloud computing to provide demand planning and to automate inventory control. Cost savings, operating efficiency, and stock accuracy showed a remarkable improvement through implementation of system- cost savings as high as 35.

The primary contribution of our research would be to merge the two parts of demand prediction modeling based on Random Forest and real-time stock monitoring through IoT, which ensure timely and accurate information regarding inventory. Therefore, the approach will eradicate manual labor, decrease the discrepancies of stocks, and hence improve the way in which decisions are made. Further, the automated restocking maintains optimum levels of inventories without facing stock out or unnecessary stocking having happened.

In fine, but some built-in limitations do exist. Instead of LSTMs, advanced architectures of deep learning that more accurately capture the high temporal dependencies in sales histories would further improve demand forecasting accuracy. Externally exerting forces on the forecasting model can thus be taken into consideration, such as general economic trends, weather, and competitor price actions.

Demand forecasting can assist small and medium-sized businesses minimise human labour and stay in stock. As a result, inventory investment will remain minimal. Concurrently increasing profits is the main focus of this approach. Forecasting helps prevent product stock-outs and excess inventory since orders are placed based on demand. Categorical embeddings in neural networks, which are still a relatively new field of neural networks that need further research, will be another intriguing method to improve accuracy in the future.

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