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AI-Driven Inventory and Demand Forecasting System with Automated Supplier Communication and Trend Analysis

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Abstraction - **The project titled "AI-Driven Inventory and Demand Forecasting System with Automated Supplier Communication and Trend Analysis" presents an intelligent stock management solution designed to optimize inventory control and improve supply chain efficiency. The system leverages advanced machine learning models such as XGBoost and Prophet to analyze historical sales data and accurately predict future product demand.**

To enhance forecasting accuracy, the system integrates real-time trend analysis using external APIs, enabling identification of high- demand products based on market and social media trends. A centralized dashboard provides live visibility of stock levels, forecasts, alerts, and purchase recommendations, supporting data- driven decision- making.The solution also automates supplier communication through email, WhatsApp, and voice calls when stock levels fall below predefined reorder thresholds. By combining predictive analytics, trend monitoring, and automated notifications, the system reduces stockouts, minimizes overstocking, improves operational efficiency, and ensures timely replenishment.

Keywords: Demand Forecasting, Inventory Management, Machine Learning, XGBoost, Prophet, Supply Chain Optimization, Predictive Analytics

I. INTRODUCTION

In today's competitive business environment, effective inventory management plays a crucial role in ensuring operational efficiency and customer satisfaction. Traditional inventory systems often rely on manual tracking or basic statistical methods, which may lead to inaccurate demand estimation, stockouts, or overstocking. These challenges increase operational costs and reduce overall profitability. Therefore, there is a strong need for intelligent and automated inventory management solutions. With the advancement of Artificial Intelligence (AI) and Machine Learning (ML), businesses can now leverage predictive analytics to make smarter decisions.

By integrating trend analysis APIs, the proposed system identifies high-demand products and adjusts inventory planning accordingly. This enhances forecasting accuracy and supports dynamic stock management. Another major challenge in inventory systems is delayed supplier communication. Manual purchase requests and follow-ups can slow down the replenishment process. To address this issue, the proposed system automates supplier communication through email, WhatsApp, and voice calls whenever stock levels fall below predefined reorder thresholds. This ensures timely restocking without manual intervention.

The system also provides a centralized real-time dashboard that displays stock levels, forecasted demand, alerts, and purchase recommendations. This transparency enables business managers to monitor inventory performance, track fast-moving items, and make data-driven decisions. Real-time visibility reduces operational risks and improves overall supply chain coordination. Overall, the AI- Driven Inventory and Demand Forecasting System combines predictive analytics, trend monitoring, and automated communication to create a smart and efficient inventory management solution. By minimizing stockouts, reducing excess inventory, and automating supplier interactions, the system enhances business productivity, scalability, and profitability in a rapidly evolving market environment.

Automation is another key factor in modern inventory systems. Manual monitoring of stock levels and communicating with suppliers can lead to delays and human

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errors. Automated alert systems ensure that when stock levels fall below predefined reorder points, suppliers are immediately notified through multiple communication channels. This reduces dependency on manual supervision and enhances operational efficiency. Furthermore, a centralized dashboard enhances decision- making by providing visual insights into stock movement, demand predictions, and supplier interactions. Real-time data visualization allows managers to quickly identify critical situations and take corrective actions.

- This system enhances supply chain resilience by enabling proactive decision-making based on predictive insights rather than reactive responses.
- By integrating artificial intelligence with automation technologies, the solution ensures higher accuracy, efficiency, and reliability in inventory operations.
- The proposed framework supports scalability, making it suitable for small businesses as well as large enterprises. It reduces human intervention, minimizes errors, and
- improves response time in critical stock management scenarios.

The intelligent forecasting mechanism helps businesses • maintain optimal stock levels while improving customer satisfaction.

Recent research has also focused on the application of Artificial Intelligence in supply chain optimization. AI- based systems are capable of self-learning and continuously improving prediction accuracy by adapting to new data patterns. Studies indicate that reinforcement learning and forecasting performance in complex and high-variability environments. These intelligent systems reduce uncertainty and support strategic planning in competitive markets.

Cloud computing and big data technologies have also been widely discussed in modern inventory management research. Cloud-based inventory platforms enable real-time data access, scalability, and centralized control across multiple locations. Researchers emphasize that integrating AI models with cloud infrastructure improves processing speed, storage capability, and system reliability. This integration ensures seamless handling of large transactional datasets generated by retail and e-commerce businesses.

Early warning systems based on AI help organizations take based forecasting reduces forecasting errors and enhances Sustainable through cost optimization are also practices decision-making efficiency in supply chain

Recent literature also emphasizes the importance of integrating external data sources into demand forecasting systems. Market trends, social media sentiment, and online search behavior have been identified as strong indicators of consumer demand shifts.

Furthermore, dashboard-based visualization systems have been studied for their impact on managerial decision-making.product leads to increased storage costs, obsolescence, and waste generation. Real-time dashboards provide transparency, improve and external APIs, protecting sensitive business data becomes

Overall, the system represents a significant step toward • digital transformation in modern inventory and supply chain management.

II. LITERATURE REVIEW

Inventory management and demand forecasting have been widely studied in the fields of operations management and data science. Traditional inventory models such as Economic Order Quantity (EOQ) and ABC analysis have been commonly used to manage stock levels. While these models are useful for basic inventory planning, they often fail to adapt to dynamic market conditions and complex the limitations of static statistical methods in handling real-time fluctuations and large datasets. With the emergence of Machine Learning (ML), modern forecasting techniques have significantly improved demand prediction accuracy. Studies show that advanced algorithms such as XGBoost.

These models can capture nonlinear relationships, seasonality, and trend variations effectively. Research indicates that ML-

preventive measures and maintain business continuity.

Research also highlights the importance of automated decision- support systems in reducing operational costs. Intelligent reorder point calculation, safety stock optimization, and lead- time prediction models contribute to cost-effective inventory control. Studies show that automation not only improves accuracy but also enhances productivity by minimizing manual workload and repetitive tasks.

Another emerging area in research is the use of automation in supplier relationship management. Automated procurement systems enable seamless order placement, status tracking, and digital documentation. Studies indicate that integrating automated communication tools such as email triggers, messaging APIs, and chatbot-based interactions reduces procurement cycle time and improves supplier responsiveness. This automation strengthens collaboration and ensures smoother supply chain coordination

management. considerations in inventory management research. Excess

Researchers suggest that accurate forecasting combined with automated reorder systems can significantly reduce environmental and financial losses. Smart inventory solutions contribute to sustainable business and transportation. Cybersecurity and data integrity have been discussed as critical challenges in AI-driven systems. As inventory platforms increasingly rely on cloud infrastructure

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monitoring, and enable quick response to critical inventory situations. Literature suggests that data visualization tools enhance strategic planning and performance tracking by presenting complex analytics in an understandable format. essential.

Automation in supply chain communication has also

Moreover, the role of data visualization and business intelligence tools has been extensively examined. Interactive dashboards allow managers to monitor Key Performance Indicators (KPIs) such as inventory turnover ratio, stockout rate, carrying cost, and forecast accuracy. Literature confirms that visual analytics improves managerial understanding and supports faster, evidence-based decision-making.

Figure 1 : Framework of Emerging Technologies in Inventory Management

III. PURPOSED SYSTEM

The main objective of the proposed AI-Driven Inventory and Demand Forecasting System is to develop an intelligent, automated, and scalable inventory management solution that enhances operational efficiency and decision-making. The specific objectives are:

- To develop an AI-based demand forecasting model using machine learning algorithms such as XGBoost product demand.
- To analyze historical sales and inventory data for identifying demand patterns, seasonal trends, and fast- moving products..
- To integrate real-time trend analysis using external APIs to improve forecast accuracy by incorporating market and social media trends.
- To automate supplier communication through Email, WhatsApp, and voice calls whenever stock levels fall below predefined reorder thresholds.
- To design a centralized real-time dashboard for monitoring stock levels, demand forecasts, alerts, and purchase recommendations.
- To reduce stockouts and overstocking by maintaining optimal inventory levels through predictive analytics..

A. SYSTEM ARCHITECTURE

The proposed AI-Driven Inventory and Demand Forecasting

gained significant attention in recent years. Research highlights that automated reorder systems and digital supplier communication reduce delays, minimize human errors, and improve by predefined thresholds ensure timely replenishment and prevent stockouts. Such systems contribute to improved coordination between retailers and suppliers.

System is designed using a modular and layered architecture that integrates data processing, machine learning, automation, and visualization into a unified framework. The system begins with a data collection layer where historical sales data, inventory records, supplier information, and external trend data are gathered from multiple sources. This data is stored in a centralized PostgreSQL database, ensuring structured storage and easy accessibility for further analysis.

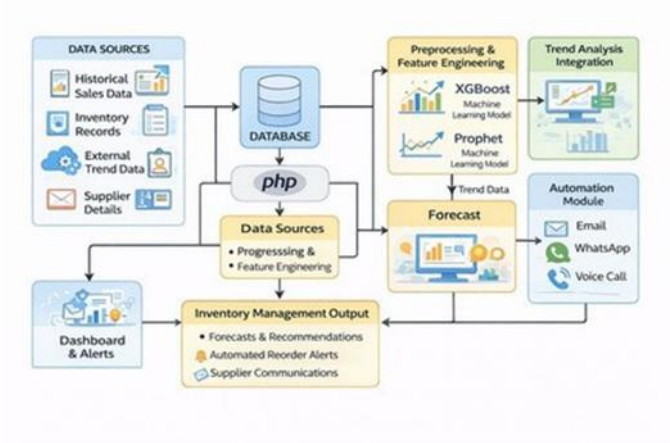

Figure 2 : System Architecture for Machine Learning–Based Inventory Forecasting and Automation

B. METHODOLOGY

The methodology consists of multiple stages including data collection, preprocessing, model development, forecasting, automation, and system evaluation.
The first stage involves data collection, where historical sales records, inventory levels, supplier information, and product details are gathered from the organization's database. The second stage focuses on data preprocessing and feature engineering. In this phase, raw data is cleaned by removing duplicate records, handling missing values, and correcting inconsistencies. The data is then transformed into a suitable format for machine learning models. The third stage is model development and training. Machine learning algorithms such as XGBoost, Prophet, Support Vector Machines (SVM), and Decision Trees are trained using historical sales data. These models analyze patterns, seasonality, and trends to forecast future product demand.

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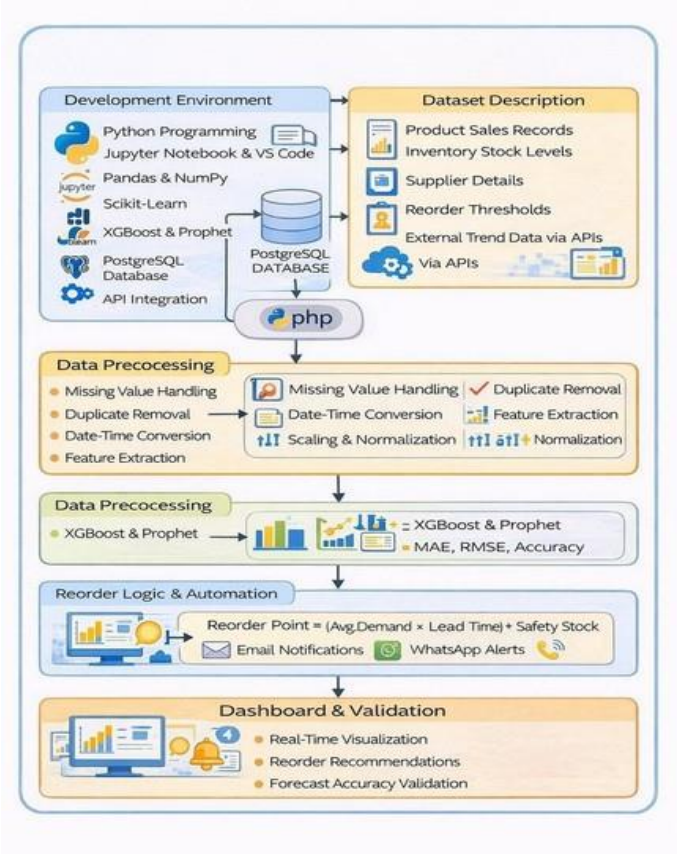

Figure 3 : Implementation Framework for Forecasting-Based Inventory Control

MODEL IMPLEMENTATION

Two primary forecasting models were implemented:

XGBoost Regressor – Used for handling nonlinear relationships and improving predictive accuracy through gradient boosting.

Prophet Model – Used for time-series forecasting to capture seasonality and trend components effectively. Both models were trained using historical data and evaluated using performance metrics such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and R-squared score. The model with the lowest forecasting error was selected for deployment.

IV. MATHEMATICAL MODEL

The inventory system in the dashboard is mathematically represented by the inventory balance equation:

It=It−1+Qt−DtI_t = I_{t-1} + Q_t - D_tIt =It−1 +Qt −Dt

1. Demand Forecasting Model

3. Stock Level Update Equation

4. Alert Trigger Function

Low stock alert condition:

$$\text{Alert} = \begin{cases} 1, & \text{if } I_t \leq ROP \\ 0, & \text{otherwise} \end{cases}$$

V. RESULT AND DISCUSION

S.No.	Classifier Algorithm	No Resampling		SMOTE	
		Accuracy	F1-score	Accuracy	F1-score
1	Logistic Regression	85.7%	0.84	84.6%	0.84
2	Decision Tree (DT)	88.9%	0.87	87.5%	0.88
3	Support Vector Maching	60.*%	0.90	89.5%	0.90
4	K-Nearest Neighbors (K-NN)	86.3%	0.86	85.4%	0.85
5	Náive Bayes (NB)	82.1%	0.86	85.4%	0.85
6	Gradient Boosting (GB)	91.4%	0.91	90.7%	0.91
7	Random Forest (RF)	**93.4%**	**0.92**	**93.0%**	**0.92**
8	XGBoost	92.1%	0.91	91.5%	0.91

Accuracy:	F1-score
Precision:	92.8%
Recall:	91.6%
F1-Score:	92.2%

Table 1 : Impact of SMOTE on Classification Model Performance

The models were evaluated using Accuracy and F1-score under standard conditions, and the results indicate that Random Forest achieved the highest overall performance with an accuracy of 93.4% and an F1-score of 0.92. Support Vector Machine (SVM) and Decision Tree also demonstrated competitive performance, while Logistic Regression showed comparatively lower accuracy.

A. System Comparison

The experimental results demonstrate that machine learning–significant improvement over traditional rule-based or threshold-driven inventory management systems. Conventional approaches typically rely on static reorder levels and manual monitoring, which often fail to adapt to seasonal demand fluctuations and dynamic market behavior.

B. Algorithm Performance

When comparing the implemented algorithms, Random Forest clearly outperformed Logistic Regression, Decision Tree, and Support Vector Machine in terms of overall accuracy and F1 score. Logistic Regression, being a linear model, struggled to fully capture complex, non-linear relationships present in inventory demand patterns, which explains its comparatively lower accuracy.

VI . CONCLUSION

He proposed machine learning–based inventory classification system successfully demonstrates how predictive analytics can enhance inventory control and supply chain efficiency. By utilizing historical sales and stock data, the system accurately categorized inventory into Low Stock, Reorder Required, Optimal Stock, and Overstocked classes. The evaluation results confirmed that Random Forest outperformed other models, achieving the highest accuracy and balanced precision–recall performance, making it the most suitable algorithm for real-time inventory classification.

Overall, the study confirms that adopting a data-driven classification framework leads to smarter inventory planning, operational responsiveness. The proposed approach provides a scalable and reliable solution for modern inventory management systems seeking predictive accuracy and real-world business impact.

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