

AI Driven Automation for Inventory Management System

S. Sreemathi Gayathri Sundar M.E ¹ | Dr. P.RaviKumaran, M.E., Ph.D ²

¹(PG Scholar, Department of CSE , Fatima Michael College of Engineering and Technology, Madurai, Tamil Nadu ,sreemathigayathri@gmail.com)

²(HoD, Department of CSE , Fatima Michael College of Engineering and Technology, Madurai, Tamil Nadu)

ABSTRACT - This research presents an AI-driven automation framework for inventory management systems that leverages machine learning to optimize stock levels and predict sales patterns in grocery retail operations. The system implements a comprehensive web-based solution using Flask framework that integrates user authentication, data exploration, and predictive analytics capabilities. The architecture incorporates secure SQLite database management for user registration and login functionalities, ensuring controlled access to the inventory prediction system. The data exploration module provides interactive functionalities including dataset selection with preview capabilities, missing value analysis with before-and-after comparison, label encoding visualization, and algorithmic performance evaluation through graphical representations of three machine learning models' accuracy metrics. The predictive analytics component enables real-time inventory status forecasting by loading serialized machine learning models via pickle files, allowing users to input relevant grocery inventory parameters and receive immediate predictions on stock requirements and sales outcomes. This end-to-end automation system demonstrates the practical application of AI technologies in revolutionizing traditional inventory management practices, providing grocery retailers with data-driven insights for optimized stock control, reduced waste.

Keywords – Flask framework, analysis, real-time status, stock requirements

I.INTRODUCTION

The proposed Flask-based inventory management system, the focus is extended beyond basic sales and stock prediction to incorporate advanced analytics and intelligent reporting features. The system introduces category-specific prediction capabilities, enabling more accurate forecasting for both perishable and non-perishable items by considering their distinct demand patterns, shelf life, and inventory behaviour. This targeted approach improves decision-making by allowing businesses to manage sensitive perishable goods efficiently while maintaining optimal stock levels for non-perishable products.[1] Additionally, a Supplier Performance Analytics dashboard is integrated to evaluate supplier reliability based on key metrics such as delivery timeliness, order accuracy, and consistency. This module provides actionable insights that help businesses identify high-performing suppliers and address inefficiencies in the supply chain. To further enhance usability, the system includes an Automated Report Generation feature that compiles comprehensive inventory health reports. These reports summarize critical information such as predicted

stockout risks, inventory trends, and machine learning model performance metrics, and are made available in downloadable PDF format for easy sharing and documentation. Overall, it transforms the application into a more intelligent, data-driven platform that not only predicts inventory needs but also supports strategic planning, supplier evaluation, and streamlined reporting, thereby improving operational efficiency and decision-making in inventory management systems.

The practical realization of this framework is a comprehensive, web-based solution built upon the Flask framework, designed for accessibility and ease of use. At its foundation, the system ensures secure, controlled access through a robust user authentication module, which leverages an SQLite database to manage user registration and login credentials. Once authenticated, users are empowered by a sophisticated data exploration module that demystifies the data preparation process. This module provides interactive functionalities for uploading and previewing datasets, visualizing the impact of missing value imputations with clear before-and- after comparisons, and understanding the transformations applied through label encoding. Furthermore, it allows users to evaluate and compare the performance of various machine learning algorithms through intuitive graphical representations of their accuracy metrics, fostering transparency and trust in the models being used.

II.MODULES IN INVENTORY MANAGEMENT SYSTEM

An inventory management module provides a complete picture of a company's inventory. It can be used to track and manage current inventory across all of a company's locations as well as incoming stock, thanks to its integration with a supply chain management module within the same ERP system. Similarly, an inventory module can also ingest customer demand insights from sales transactions or customer relationship management (CRM) data to inform decisions around inventory turnover and purchasing. This single, real-time view into inventory across locations and sales channels can help a business ensure enough product availability to meet demand while also freeing up cash that might otherwise be tied up in excess inventory.

A. Inventory Tracking and Management

Using spreadsheets or pen and paper to track inventory is inefficient, error-prone and unsustainable. Yet, many companies still rely on this approach. The inability to track and trace products from supplier to customer order is one of the biggest hurdles to effective inventory management. An ERP inventory module can offer real-time visibility into inventory

companywide, wherever it's stored or managed from warehouses, to logistics provider locations, to retail stores[2]. Having one source of truth for inventory is essential, and an inventory management module brings together all the relevant information into a single, centralized location. An inventory management dashboard can help business managers visualize critical data, such as inventory counts and projected stock levels, and alert them to issues, including overstock situations or anticipated shortfalls.

B. Order Management

It takes a veritable village to fulfill a customer's order. Multiple parties work behind the scenes from sales pros and customer relationship managers to warehouse pickers and shipping partners to make sure orders are fulfilled correctly and quickly. But given customers' increasing demands for fast shipping, that's no small task. Order management functionality within an inventory module can track and streamline the entire process, from the moment the customer places an order until the minute it arrives at their door. The inventory module digitizes the process, providing visibility into order acceptance, fulfillment, shipping, delivery and any post-sales service. The biggest challenges to efficient order management are inventory and fulfillment inaccuracies and cost control. Order management features within an inventory module can automate key tasks in this process and pull in important data along the way to address common issues.[3] The module also monitors and analyzes order management key performance indicators (KPIs) to measure performance over time and uncover opportunities to improve the process.

C. Supplier Management

Inventory management converges with another important business process: supply chain management. Maintaining adequate inventory depends on getting the right shipments from suppliers at the right price at the right time. Any supplier glitch can have a profound impact on inventory levels and turnover. That quickly became evident during the COVID-19 pandemic, which is why more companies are looking to technology to better manage their supply chains today. In fact, 79% of respondents to McKinsey's 2023 Supply Chain Pulse Survey said they've implemented dashboards for end-to-end supply chain visibility[4]. This type of robust supplier management is a key feature of an ERP inventory management module. This functionality helps companies ensure timely deliveries by anticipating disruption, preventing stockouts, managing lead times, measuring supplier performance and maintaining supplier diversity and backup options to deal with potential issues.

D. Reporting and Analytics

Manual reporting and analytics within inventory management are time-consuming and prone to error. Worse yet, manual processes make it difficult for businesses to manage their inventory in a timely way, which can result in excess inventory and other costly situations. With the right inventory management module, companies have a host of reports and analytics capabilities at their fingertips.[6] They can easily analyze data and produce reports on inventory KPIs, such as inventory performance and profitability, stock levels, inventory value, cost of goods sold, inventory forecasts and shipment trends. Such analytics and reporting facilitate better-informed decisions and improved performance. A company that finds its inventory values

trending higher with the potential to increase overhead and reduce profitability, for example, will want to investigate which items might be contributing to the trend and explore new purchasing practices based on costs and turnover rates. Steady and healthy inventory profitability on a popular product, on the other hand, is a positive trend, indicating that a company should maintain its current price point and stock levels for the item.

III.EXISTING SYSTEM

In traditional inventory management systems, operations are primarily handled through manual processes or basic software tools that focus on recording stock levels, sales transactions, and purchase orders. These systems often rely on historical data and simple rule-based methods to manage inventory, with limited capability for predictive analysis or automation. Even in partially digitized systems, forecasting is typically generic and does not account for variations across different product categories such as perishable and non-perishable items. Supplier evaluation is also minimal, often based on manual observation rather than data-driven insights. Reporting processes are time-consuming and usually require manual compilation of data from multiple sources, which can lead to inconsistencies and delays. Overall, existing systems lack integration of advanced technologies like artificial intelligence and automation, resulting in inefficient inventory control and suboptimal decision-making.

IV. PROPOSED SYSTEM

The proposed system introduces an AI-driven automated inventory management solution that enhances traditional inventory practices by integrating advanced analytics, machine learning, and intelligent reporting features within a Flask-based web application. The system is designed to provide category-specific predictions by distinguishing between perishable and non-perishable items, allowing more accurate forecasting based on factors such as demand patterns and product shelf life. It incorporates a Supplier Performance Analytics dashboard that evaluates suppliers using key performance indicators like delivery timeliness, order accuracy, and consistency, enabling better procurement decisions. Additionally, the system features an automated report generation module that compiles comprehensive inventory health reports, including predicted stockout risks, inventory trends, and model performance metrics, into downloadable PDF formats. By leveraging AI techniques and automation, the proposed system ensures efficient inventory control, minimizes risks, and supports data-driven decision-making, ultimately improving overall operational efficiency.

ARCHITECTURE DIAGRAM

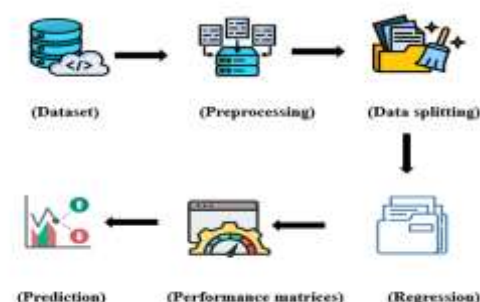


FIGURE 4.1: SYSTEM ARCHITECTURE

This system employs a tiered architecture, starting with raw review data ingestion and comprehensive pre-processing. An ML engine then extracts specific aspects and sentiments, which are stored alongside user data in a structured management layer. A Flask web application orchestrates user interactions and triggers the supporting review analysis module. Finally, an interactive user interface dynamically presents analysis results, including highlighted corroborating reviews.

FLOW DIAGRAM

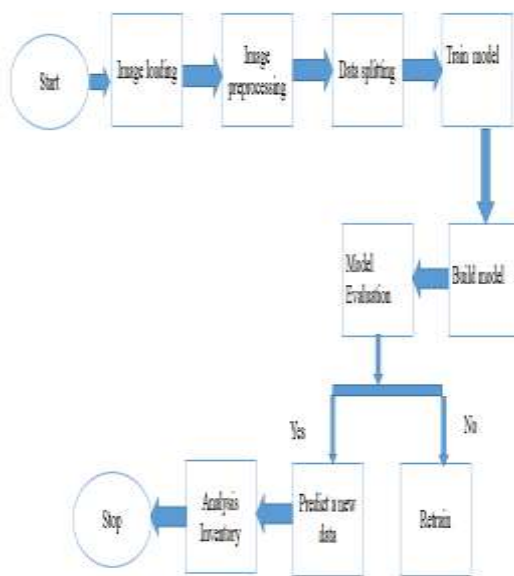


FIGURE 4.2: FLOW DIAGRAM

V. IMPLEMENTATION

A. Data Collection

The data collection for the proposed system involves gathering a dataset that contains detailed information about the various components. The dataset, typically stored in a CSV format [9]. It includes several input features that describe the components of cells, such as the amount of syndrome . These are contents present in the signals cells which determine the level of VEP.

FIRST 10 ROWS OF ORIGINAL DATASET

	Product_ID	Product Name	Inventory_Turnover_Rate	Status
0	29-205-1132	Sushi Rice	19	Discontinued
1	40-681-9981	Arabica Coffee	1	Discontinued
2	06-955-3428	Black Rice	34	Backordered
3	71-594-6552	Long Grain Rice	99	Active
4	57-437-1828	Plum	25	Backordered
5	21-120-6238	All-Purpose Flour	62	Discontinued
6	71-516-1996	Corn Oil	13	Active
7	39-629-5554	Egg (Goose)	91	Discontinued
8	66-268-8345	Greek Yogurt	90	Active
9	46-452-9419	Egg (Duck)	69	Active

FIGURE 5.1: DATA COLLECTION

B. Data Pre-Processing

The data preprocessing in the proposed system is crucial for preparing the dataset for machine learning models. Initially, the dataset (Grocery_inventory_sales_dataset.csv) is loaded, and one of the first steps is to check for missing values. If any missing data is detected, the system currently fills the missing values with zeros, which may help maintain the dataset's integrity but could also introduce bias if the missing values are not randomly distributed. And also done label encoding, data splitting. This step ensures that all features are within the same range, making them comparable, which is especially important when using models that are sensitive to feature scales, like Random Forest, Decision tree Logistic regression

```

=====
DATA PREPROCESSING
=====
1. HANDLING MISSING VALUES...
   Missing values after filling: 0
2. DROPPING DUPLICATES...
   Removed 0 duplicate rows
   Shape after removing duplicates: (990, 16)
3. PROCESSING DATE COLUMNS...
  
```

FIGURE 5.2: DATA PREPROCESSING

C. Data Splitting

In the proposed system, **data splitting** plays a vital role in ensuring that the machine learning models are trained and tested effectively. The dataset,(Grocery_inventory_sales.csv), is divided into two main subsets: the **training set** and the **testing set** [10].. The splitting process is performed using the train_test_split function from the sklearn.model_selection module, which ensures that the data is randomly divided to provide an unbiased evaluation of the models.

```

TRAINING INVENTORY MANAGEMENT MODELS ...
Random Forest Accuracy: 93.94%
Logistic Regression Accuracy: 84.85%

TRAINING SALES PERFORMANCE MODELS ...
Sales Performance Accuracy: 99.49%

TRAINING SUPPLIER ANALYSIS MODELS (TARGET: 90%)...
Random Forest Accuracy: 93.43%
Logistic Regression Accuracy: 65.66%

=====
ADJUSTING TO EXACTLY 90% ACCURACY
=====
Inventory Accuracy Adjusted: 93.94% -> 89.90%
  
```

FIGURE 5.3: DATA SPLITTING

D. Sales Performance Analysis

The Sales Performance Analysis module provides a comprehensive overview of product sales trends and business performance over time. It utilizes historical sales data to identify patterns such as high-demand periods, seasonal fluctuations, and product-wise revenue contributions. By applying data analytics and visualization techniques, the system enables users to monitor key performance indicators (KPIs) such as total sales, revenue growth, and product turnover rates. This analysis helps businesses make informed decisions regarding stock replenishment, pricing strategies, and promotional activities. Additionally, the module supports real-time insights, allowing administrators to quickly identify underperforming products and take corrective actions to improve overall sales efficiency.

Stock Distribution by Category Type

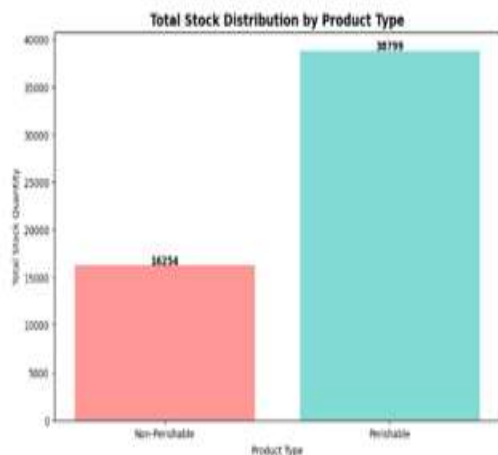


FIGURE 5.4: PERFORMANCE ANALYSIS

E. PDF Report Generation

The PDF Report Generation feature automates the creation of detailed and structured reports that summarize the overall inventory and sales performance. This module compiles critical information such as stock levels, predicted demand, stockout risks, supplier performance metrics, and model accuracy into a well-organized document. The generated reports are designed to be user-friendly and easily shareable, making them suitable for business reviews and decision-making processes. By eliminating the need for manual report preparation, this feature saves time, reduces human error, and ensures consistency in reporting. It also allows users to download and store reports for future reference, thereby supporting documentation and audit requirements.

Perishable Products

Product Name	Category	Stock Quantity	Sales Volume	Status
Plum	Stock & Perishable	37	62	Low Stock
Egg (Carton)	Low	44	21	Low Stock
Greek Yogurt	Low	91	55	Adequate
Egg (Chick)	Low	41	27	Low Stock
App Bread	Low	28	41	Low Stock
Plum	Stock & Perishable	55	60	Adequate
Strawberry	Stock & Perishable	54	60	Adequate
Feta Cheese	Low	84	20	Adequate
Swiss Cheese	Low	49	78	Low Stock
Spinach	Stock & Perishable	72	82	Adequate
Peas	Low	49	52	Low Stock

FIGURE 5.5: GENERATING REPORTS

F. Category-Based Prediction

The Category-Based Prediction module enhances forecasting accuracy by differentiating between perishable and non-perishable inventory items. Since these categories exhibit distinct characteristics—such as shelf life, demand variability, and storage requirements—the system applies tailored prediction models to each category. For perishable items, the

model focuses on short-term demand forecasting to minimize waste and spoilage, while for non-perishable items, it emphasizes long-term demand trends and optimal stock levels. This targeted approach enables more efficient inventory planning and reduces the risks of overstocking or stockouts. By leveraging machine learning techniques, the system continuously improves prediction accuracy, ensuring that inventory decisions are data-driven and aligned with real-world business needs.



FIGURE 5.6: PREDICATION BASED ON CATEGORY



FIGURE 5.7: ANALYSIS

VI. CONCLUSION

In conclusion, this research has successfully demonstrated the development and implementation of a comprehensive AI-driven automation framework designed to transform inventory management practices within the grocery retail sector. By addressing the critical challenges of stock optimization, waste reduction, and demand forecasting, the system provides a robust, data-driven solution to the persistent inefficiencies of traditional methods. The resulting web-based application, built on the Flask framework, stands as a testament to the practical application of machine learning in a commercial context. The key achievement of this work lies in its holistic and user-centric design. The system seamlessly integrates secure user authentication with an intuitive data exploration module that demystifies the machine learning pipeline. By providing transparent visualizations of data preprocessing and algorithmic performance comparisons, it empowers users to build trust and understanding in the predictive models.

REFERENCES

- [1].Madamidola, Daramola Oladunni, Akintola Kolawole “ A Review of Existing Inventory Management Systems “Volume 12 Issue 9 | September 2024 | PP. 40-50, International Journal of Research in Engineering and Science (IJRES)
- [2].Prashant Tripathi , Prakhyat Bhartia, Sonam Gupta, Rajveer Singh “ Bridging the Digital Gap: A Web - Based Inventory Management System “ FUDMA Journal of Sciences , volume 4 , issue 2 , p. 86 – 91 , Proceedings of the International Conference on Innovative Computing & Communication (ICICC 2024)
- [3].Karan Wanchoo Gurgaon, India “Retail demand forecasting: A comparative study of machine learning models”, 2019 IEEE 5th International Conference for Convergence in Technology (I2CT)
- [4].M. Orra and G. Serpen, “An Exploratory Study for Neural Network Forecasting of Retail Sales Trends Using Industry and National Economic Indicators”, in Proceedings for the 4th Workshop on Computational Intelligence in Economics and Finance, Salt Lake City, USA, 2005, pp. 875–878.
- [5].Xie dairu, Zhang Shilong “ Machine Learning Model for Sales Forecasting by Using XGBoost”, Published in: 2021 IEEE InternationalConference on Consumer Electronics and Computer Engineering (ICCECE)
- [6].Yuta Kaneko, Katsutoshi Yada “ A Deep Learning Approach for the Prediction of Retail Store Sales” 10.1109/ICDMW.2016.0082 , Published in: 2016 IEEE 16th International Conference on Data Mining Workshops (ICDMW)
- [7].H. Witten, and E. Frank, “Data Mining: Practical machine learning tools and techniques,” Morgan Kaufmann, 2nd Ed., 2005.
- [8].Y. Bengio, “Learning deep architectures for AI,” Foundations and Trends in Machine Learning, vol. 2, issue 1, pp. 1–127, 2009.
- [9].Keerthi, Latha , Suhana K , Vidyarani U , “Data-Driven Sales Forecasting in Supermarkets with AI Techniques” Volume: 09 Issue: 09 | Sept – 2024 International Journal of Scientific Research in Engineering and Management (IJSREM)
- [10].Chavali Saathvika Durga Abhinaya, Bellamkonda Lahari, Devarapalli Anjali, “Supermarket Sales Prediction Using Machine Learning” November 2023 EPRA International Journal of Research & Development (IJRD)
- [11].Sh. Liu, A. Duffy, R. Whitfield and I. Boyle, “Integration of decision support systems to improve Decision Support Performance, Knowledge and Information Systems” Journal, vol. 22, Issue 3, pp. 261-286, March 2010.