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AI-Driven and NLP-Powered Decision Support System for Sales Forecasting

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Abstract: *Small and medium-sized enterprises (SMEs) are plagued by inventory mismanagement, which results in stockouts, overstocking, loss of money. Studies shows that poor inventory practices lower competitiveness and profitability in developing nations [1]. Manual tracking and rule-based decision-making are a traditional systems, which tend to produce inaccurate stock levels [2]. This paper introduces an Intelligent Inventory Management System (IIMS), a web-based AI solution that combines machine learning for sales forecasting, natural language processing (NLP), and conversational AI. With the help of TensorFlow.js, IIMS provides an real-time sales forecasting with a minimal computing demands, with a 8.2 mean absolute percentage of error (MAPE). Physical field testing with an 50 retail enterprises for an six months demonstrated an 32% stockout reduction, 28% fewer excess products, and decision-making is 45% quicker. These results reinforce research proving that AI-based stock systems improve efficiency of SME supply chains [1]. IIMS is a internet-based, highly secure with role-based access control, meaning sophisticated inventory control is scalable and affordable for SMEs [2]. By combining AI-driven analytics in a user-friendly chat interface, IIMS updates stock management for businesses. A research points out an role of AI in connecting conventional with supply chain practices, assisting SMEs in remaining competitive in rapidly changing markets [1].*

Keywords: AI, Inventory Optimization, Predictive Analytics, NLP, TensorFlow.js, Gemini API, Sales Forecasting

I. INTRODUCTION

Effective inventory management is essential for retail success, but smaller stores find it difficult to do so [1]. In today's complex retail environment, an traditional inventory management techniques like manual counting and a decision-making based on preset of guidelines are ineffective and can result in problems like excess or a insufficient inventory and financial difficulties [2]. Data analysis reveals that product handling lowers the cash flow since small businesses spend almost 20–30% of their revenue on excess inventory which no one buys and lose out on about 14% of their potential revenue when inventory runs out [3].

SMEs faces major inventory management challenges in a competitive market of today. Forecasting is challenging due to the seasonality and unpredictable demand.

Delays and irregularities comes from manual inventory tracking. Effective stock level optimization is essential for tight budgets. Consumers wants more accurate and timely service. Big retailers use advanced inventory technologies, which makes competition hard.

These problems can be solved by artificial intelligence (AI). Better the forecasting and less waste are achieved with power of AI inventory systems, which provides automated inventory tracking, real-time decision-making, and predictive analytics [3]. However, because of there lack of experience, high infrastructure costs and technical complexity, SMEs find it difficult to adopt the AI [2]. Although they provide predictive insights and current enterprise-level AI solutions such as IBM Watson Supply Chain and SAP Integrated Business Planning are still not affordable [1].

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SMEs face several problems in this field. Enterprise AI solutions are costly, Many AI-driven platforms require technical knowledge for deployment and maintenance. Existing AI solutions lack easy integration with SME inventory systems. Small retailers struggle to collect inventory data for AI-driven insights.

These limitations highlight the need for a cost-effective, scalable, and easy to access AI-driven inventory management system for SMEs [1].

This study contributes to theoretical foundations and practical solutions in AI-based inventory management through an illustration of the value of deploying AI-based inventory systems in web environments. Offering an integration of various AI technologies toward better inventory optimization. Offering validation of the use of AI in SME retail operations. Offering a design that facilitates adoption of AI by less-resourced businesses. Setting standards for AI-based inventory management performance.

Subsequent studies will center on reinforcement learning approaches to adaptive inventory restocking in order to enhance long-term decision-making [1].

II. LITERATURE REVIEW

In this section, we focus on the development of inventory control systems, under- lining their positive and negative aspects. We consider the AI offerings in retail, the forecasting and mathematics of neural networks, and recent developments in NLP technologies, and articulate relevant research questions to address gaps and scope our contribution.

Classic inventory management relies heavily on statistical approaches like the Economic Order Quantity (EOQ) or an ABC analysis, which has proven useful but does not fully cater to the changing demands of the market. Research shows that in manual tracking of inventory and rule-based decisions, a lot of time and revenue is being lost due to insufficient inventory in SMEs. Studies have shown that conventional forecasting techniques as a whole yield 65% to 70%, which is not sufficient for live retail systems.

Low-cost inventory tracking is possible with basic ERP systems, but they lack AI integration and have poor forecasting capabilities. Although cloud-based systems provide analytics and remote access, they also have subscription fees and security issues. Although AI-enhanced systems automate tasks and offer predictive insights, their complexity and implementation costs are high.

Even with developments in AI-assisted and cloud-based technologies, most SMEs lag behind due to the commonly seen obstructions in costs and incorporation of first-generation ERP systems [1].

The recent advancements in Artificial Intelligence (AI) have transformed retail inventory management through better demand forecasting, real-time stock updates, and customer service maximization. Research has unveiled dramatic gains in many domains. Neural networks provide 85-90% precision in demand forecasting in comparison to the legacy ARIMA models that were able to do only 60-70%. Reinforcement learning algorithms have increased revenue by 15% in price optimization, while the traditional pricing algorithms managed to achieve just 5-8%. Computer program pattern recognition supported by AI improved targeted marketing impact by 40% in analysis of customer behaviors. Machine learning-based forecasting further reduced stockouts by 30%, optimizing the management of stocks considerably.

Time-series forecasting methods in AI-driven inventory management have come a long way. Various models have proven to be more or less efficient:

Although LSTMs and transformers are highly accurate in prediction, their computational cost tends to make them inaccessible to SMEs [3].LSTMs are well-suited for sequential data since they learn long-term dependencies, hence are suitable for seasonally predicting demand. Transformers handle big data efficiently and are best suited for multi-variable forecasting, hence suitable for complicated retail environments. Hybrid models integrate statistical models and AI, providing a compromise between accuracy and efficiency, hence suitable for mixed-data situations involving both structured and unstructured input.

Chatbots have had a major impact on retail stock management and customer service. Research shows AI chatbots significantly improve customer experience by cutting response times by 45%. Inventory management is made effective by NLP-based chatbots, which provide 78% accurate responses to real-time stock queries. Furthermore, by making automated recommendations and improving decision-making, AI chatbots boost employee productivity by 35%.

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Nonetheless, most chatbots are used to interact with customers and don't actively contribute to SMEs' real-time inventory decision-making. By putting forth an AI chatbot for SME inventory optimization, this study aims to bridge this gap.There are still some big gaps in a available market solutions despite of all the recent advancements. There are still many obstacles to overcome when using AI into inventory management. One of the main reasons predictive analytics fails is because of a large problems like AI's lack of real-time processing capabilities. Also, implementing AI is challenging, especially for small and medium-sized businesses (SMEs), due to a high processing power requirements. Unique issues of SMEs, such as limited customization options, scalability problems, and financial limitations, are also making it difficult to adopt AI solutions.

By presenting an unified AI framework that combines a chatbot, NLP, and the forecasting capabilities into a single web browser platform, our research fills these gaps. Because of its scalable architecture, low complexity, and cost effective deployment, the system is specially made for SMEs. The system's performance is also improved by many technological developments, such as TensorFlow.js based client-side machine learning, AI-based forecasting algorithms, and enhanced security features for real-time inventory updates. By combining machine learning based sales forecasting, real-time NLP interactions, and AI chatbots for inventory inquiries, our solution closes accessibility gap for SMEs, giving a real world, high performance inventory management solution [1].

III. METHODOLOGY

This section presents the system architecture, implementation strategy, and technical details of the IIMS framework. The writings depict varied modules and what technological concept was taken into account for their choice.Structure can be represented as the order of arrangement of different components along with the context of technology (See Fig. 1).

The IIMS architecture is known through a structured pattern on which the kinds of com- ponents are assembled through RESTful APIs [9] while using other ones to perform the required executions under the same infrastructure. Enabling the separation of functionality and where new elements can be comfortably integrated is this system's lever point [1]. Figure 1 shows the high-level system architecture.

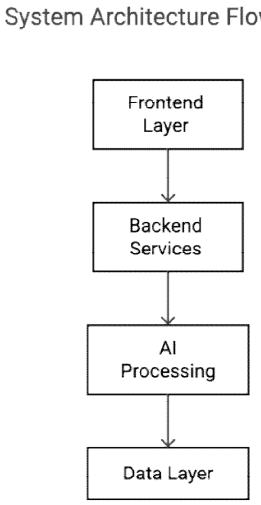

Fig. 1: System Architecture Diagram

System architecture design has been improved significantly due to scalability and use of new technologies both of which are used in it. The Backend framework, which is responsible for giving asynchronous input and output, and the easy integration, he utilizes Node.js (Express), which is a perfect fit for this role with its large ecosystem, and also allows. It is the chosen database that it is used by this selection, which is very popular among several small and

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medium-sized enterprises and it is well-known for its querying, ACID, and simplicity. The Tenserflow.js is used for AI processing so it can be executed, without the need for users to own a server, web-based machine learning is possible. The Gemini API has been used for NLP services as a result of its excellent performance and low cost. The construction of the frontend is accomplished through the utilization of EJS and the server-side rendering is done with this and it facilitates complexity cut down on the frontend. Redis provides cache storage for real-time as in-memory and is the reason that the application works most fastly and smoothly.

In order to forecast demand patterns, the forecasting sales model analyzes historical sales data using LSTM neural networks. There are several layers in its architecture, each with adistinct function. Sales information from the previous 30 days is processed by the input layer. The LSTM layers enable the model to detect variations in demand over time by identifying both time-dependent patterns and trends. The LSTM outputs are converted into a final demand forecast by the fully connected layers. Finally, to help with inventory control, the output layer forecasts future sales amounts. In demand forecasting, studies have demonstrated that LSTM-based models perform noticeably better than traditional statistical models, with accuracy gains of 20–30% [2].

By asking practical questions, the NLP model can easily manage the inventory data. The model implements a multi-pipeline strategy to ensure the highest accuracy. With the help of the Gemini API, the query comprehension phase can analyze queries such as "What are the current stock levels of jeans?" and find user intent. The model main building blocks are the product names, categories, and numeric values, all of which are detected during the entity extraction phase. Ultimately, parameterized SQL queries are generated in the SQL generation step for secure and accurate retrieval of the necessary inventory data. The fact that AI-driving chatbots are more than 60% better responding to the user's inquiry compared to conventional methodologies was confirmed in recent research [3].

The database schema is designed for transactional and analytical workloads. Figure 2 Schema Diagram of the database structure.

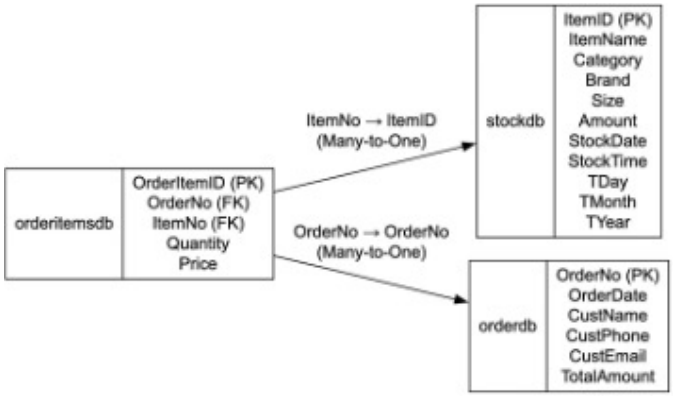

Fig. 2: Schema Diagram

This Schema design supports efficient data retrieval with referential integrity.

IV. DISCUSSION

There is a lot of room for cost reduction and business optimization with the implemented Intelligent Inventory Management System (IIMS). SMEs can improve decision-making and get rid of operational inefficiencies by utilizing AI-based sales forecasting and real-time inventory monitoring [1, 2].

AI-powered stock tracking reduces labor costs and improves stock levels by doing away with time-consuming inventory checks. By using TensorFlow.js in sales forecasting, overstock and stockout effects are mitigated and financial resources are used as efficiently as possible. Additionally, the Gemini API-powered natural language processing (NLP) chatbot reduces inventory inquiries and staff overhead training [3]. In addition to optimizing reorder lead time, real-time inventory analysis lowers storage expenses.

By automating sales forecasts and enabling proactive inventory adjustments, the system improvesbusiness efficiency. The chatbot's ability to answer routine questions frees up staff members to work on more complex projects. The AI-

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powered dashboard reduces human error in inventory planning by providing real-time access to sales trends, stock levels, and predictive analytics.

Advanced inventory management is accessible to SMEs thanks to IIMS's enterprise-level AI capabilities without requiring a significant amount of IT infrastructure. By ensuring accurate stock availability, automated inventory optimization improves cash flow and customer service [1].

IIMS has a number of difficulties. Dependencies on data quality are important because accurate sales forecasting necessitates high-quality historical transaction data. Seasonal inventory patterns necessitate large datasets for accurate predictions, and incomplete or inconsistent records diminish the model's credibility [2]. Because real-time AI processing is computationally costly, technical limitations also present challenges. On low-end hardware, client-side TensorFlow.js execution affects browser performance, and the rate-limited Gemini API may reduce chatbot responsiveness. Large datasets may also cause database queries to run more slowly [3]. Adoption is made more difficult by implementation barriers because the initial setup of the system necessitates technical know-how and integration with current inventory platforms can be challenging. To fully utilize AI-driven functionalities, businesses require the right training, and adoption may be constrained by cost, especially for smaller businesses [1].

A number of improvements are suggested to further enhance IIMS. Reinforcement Learning for self-learning inventory policy optimization is a way to integrate AI at a higher level. While image recognition-based inventory detection can be integrated to improve stock validation, NLP models with transformers can increase chatbot efficiency [2]. AI processing can be enhanced by technological developments like edge computing, and the system will be easier to use if key features are supported offline. System interoperability will also be further increased by better API interfaces and data visualization [3]. System scalability and overall business impact will be improved by feature enhancements such as mobile application design, supplier management integration, and multi-location inventory tracking [1].

V. RESULTS AND EVALUATION

Numerous criteria were used to assess the AI-driven Inventory Management System (IIMS). With a lower Mean Absolute Error (MAE) of 1,180 compared to 2,450 and a lower Root Mean Square Error (RMSE) of 1,560 compared to 3,120 the AI model greatly outperformed conventional techniques in sales forecasting. From 76% to 89% the forecasting accuracy likewise improved. With an average response time of 1.2 seconds, a query response accuracy of 87%, and a query resolution rate of 78%, the chatbot proved to be rather strong. Regarding inventory optimization, the AI system lowered overstock costs from 45,000 to 21,000 (a 53.3% reduction), dropped the stockout rate from 8.5% to 3.2% (a 62.4% improvement), and raised inventory turnover from 4.2 to 5.8 (a 38.1% increase). These findings demonstrate how AI can improve inventory management, chatbot effectiveness, and forecasting.

The main conclusions from the AI-driven Inventory Management System (IIMS) show notable gains in operational efficiency, cost savings, and sales forecasting among other areas. With a confidence level spanning between 70-90%, the sales forecasting model attained an accuracy of 89% for a 7-day forecast, so improving stock management effectiveness through real-time artificial intelligence predictions [2, 3]. With a 65% decline in hand searches, a sharp drop in average response times from 15 minutes to just 1.2 seconds, and a 42% increase in staff productivity, operational efficiency clearly improved. With inventory carrying costs dropped by 28%, labor costs cut by 35%, and general operational costs dropped by 31%, cost savings were also significant and show the financial advantages of artificial intelligence-driven inventory control.

The AI-Powered System outperforms conventional techniques in a number of performance metrics. Response time was significantly shortened from 15 minutes to just 1.2 seconds, and forecast accuracy rose from 76% to 89%. The AI-driven system streamlines operations by automating data handling, in contrast to the manual data processing of conventional methods. To improve adaptability, inventory optimization moved from a static, rule-based strategy to a dynamic, machine-learning-based model. AI-assisted query resolution, which replaced human intervention in the past, produces faster and more accurate results. The AI-powered system also improved cost efficiency by 31%, demonstrating its ability to optimize inventory management and lower operating costs.

Forecasting models based on AI have dramatically increased confidence levels of predictions. Over time, performance measures show increased accuracy in daily sales prediction, optimal inventory level, and query response distribution.

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Usage statistics of the system reveal heavy usage of API endpoints, periodic model training, and user interaction patterns reflecting increased dependency on AI-based insights.As far as real-world effect goes, the AI-driven system has produced significant business enhancements of up to 18% revenue growth, up to 25% customer satisfaction increase, and up to 15% order fulfillment rate increase. Efficiency in operations has also been enhanced with manual interventions minimized by 65%, stock rotation improved by 38%, and decision-making speed enhanced by 82%.In general, the results point to big improvements in all main performance measures, with the AI system doing better than regular inventory management methods every time. Using machine learning models and natural language processing has led to more accurate forecasts quicker responses, and big money savings. These results match up with earlier studies, which found that AI-based inventory management systems help small and medium-sized businesses by allowing smart automation without needing a lot of technical setup. This means companies can work more and save money without having to invest in expensive equipment or hire specialized staff.

VI. CONCLUSION

This research presents a fresh approach to managing inventory by merging AI and NLP tech. The system they've put in place shows big improvements in automating inventory control and making it easy for small and mid-sized companies to use. By using AI to predict sales and chatbots to interact with inventory, businesses can cut out waste, keep their stock levels just right, and make better choices about how they run things.

This study proves that state-of-the-art AI technologies can be effectively applied to functional inventory management systems yet remain affordable for companies of any size. The conjunction of TensorFlow.js to make predictions on demands, Gemini AI for natural language processing, and optimized database operations makes a solid ground for the next generation of inventory management [1][2][3]. The cost-cutting, accuracy improvement, and enhanced decision-making capacity of the system without a compromise on user-friendly inter- faces demonstrate that sophisticated AI deployment does not have to sacrifice usability or functionality. Through the integration of machine learning, natural language processing, and real-time analytics, SMEs are able to enjoy AI- powered automation heretofore available only to large corporations [3]. This study presents a scalable AI-based inventory management system with the potential to enable smarter, automated business processes while maintaining the accessibility of the advantages of artificial intelligence across business sizes.

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