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Development of a Decision Support System for Inventory Management in a Pharmaceutical Retail Outlet

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ABSTRACT

This study presents the development of a Decision Support System (DSS) designed to enhance inventory management in a pharmaceutical retail outlet. The system integrates key parameters such as demand rate, lead time, and stock-level data to accurately predict the reorder point for each medicine. Once predictions are generated, the DSS compares actual stock levels with forecasted requirements and sends advisory feedback to the managerial team on the state of inventory. This ensures timely reordering of essential drugs, minimizing the risk of stockouts while preventing excess inventory. By supporting data-driven decision-making, the DSS enables the optimization of inventory levels and ordering processes, leading to improved customer satisfaction, reduced operational costs, and more reliable access to critical medications. In addition, the application incorporates a user-friendly interface and graphical features that simplify data visualization and interpretation, making it easier for managers to analyze inventory trends and respond effectively to changing demand patterns.

Keywords: Decision Support System (DSS); Inventory Management; Pharmaceutical Retail; Convolutional Neural Network (CNN); Optimize Inventory; Reorder Point

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1. INTRODUCTION

Retail pharmacies face significant challenges in inventory management. Medicines differ in cost, demand rates, and lead times, making it difficult to balance between excess stock and stock-outs. Excess inventory ties down capital, whereas shortages result in lost sales and reduced customer satisfaction. Traditional inventory management models are often insufficient in handling the dynamic nature of pharmaceutical demand. Decision Support Systems (DSS) have been applied in several industries to improve decision-making by combining data, analytical models, and user-friendly interfaces [1], [2]. In inventory management, DSS can forecast demand, optimize reorder points, and support supply chain efficiency [3], [4]. However, limited work has focused on applying DSS to pharmaceutical retail outlets where variability is high and customer service is critical. Recent advances in artificial intelligence (AI) and deep learning provide opportunities for more intelligent DSS designs. Convolutional Neural Networks (CNNs) have been successfully applied to product recognition and classification in retail [5], [6]. Integrating CNNs with DSS can enhance automation by enabling drug recognition and database retrieval through image scanning. This study develops an intelligent DSS for pharmaceutical inventory management by combining reorder point analysis with CNN-based drug recognition. The system predicts reorder points, provides real-time feedback to management, and improves decision-making efficiency.

DSS research began in the 1970s with a focus on interactive computer-based systems for decision-making [2]. Subsequent studies expanded DSS applications to management, healthcare, and logistics [7], [8]. In pharmaceutical supply chains, DSS has been shown to improve stock control and resource allocation [9], [23]. Several studies have explored intelligent forecasting and optimization in pharmaceutical inventory. A fuzzy-aided DSS for inventory control demonstrated effectiveness in handling uncertain demand [29], while Ogwo et al. [28] presented a computer-based drug sales and inventory control system for retail pharmacies. Case studies on pharmaceutical supply chain forecasting emphasize the importance of accurate models to avoid overstocking and shortages [30]. Deep learning has significantly enhanced decision support applications. Zhang et al. [10] applied deep learning to demand forecasting in retail supply chains, while Kaur and Singh [11] systematically reviewed AI-driven DSS in inventory management. Chen et al. [12] proposed a deep learning-based DSS for pharmaceutical supply chain management, and Adepoju and Akinlabi [13] introduced a hybrid AI framework for pharmacy inventory optimization. Industry 4.0-based system-dynamics approaches have also been applied for collaborative demand management in pharmaceutical contexts [18].

In recognition tasks, CNNs have proven powerful for medicine and retail product identification. Wei et al. [5] developed CNN-based retail recognition methods, while Adewumi [14] proposed CNNs for pill image retrieval. Ou et al. [24] further advanced pill detection using enhanced feature pyramid networks, and Shrirao and Handore [17] designed an Android CNN-based recognition system for visually impaired patients. More recently, Asfand-e-yar et al. [20] proposed multimodal CNNs for pharmaceutical safety monitoring, while mobile recognition systems based on deep learning (e.g., ResNet101) have been applied for medication identification [31]. Forecasting approaches beyond classical models include LSTM-based methods for predicting pharmaceutical demand [25], [26], and factorization machine approaches for retail sales forecasting [27]. In developing regions, studies have highlighted persistent challenges in forecasting practices in public pharmaceutical supply chains [32]. Recent efforts have also emphasized real-time tracking and optimization.

Studies by Agarwal et al. [23] and Tiwari and Carpitella [21] discussed structured pharmaceutical inventory models, while research on AI-driven Vendor Managed Inventory (VMI) systems [22] and cost–benefit analyses of real-time tracking [19] highlight practical advantages of intelligent inventory solutions. Despite these advances, few works directly integrate CNN recognition modules with DSS for pharmaceutical retail inventory management. This gap motivates the present study, which combines reorder point prediction with CNN-based drug recognition to enhance decision-making.

2. MATERIALS AND METHODS

The system is composed of four main modules, following a systematic process designed to support the structured development of the software package.

2.1. Database

A structured relational database stores historical demand rates, stock levels, and lead times for medicines.

2.2. Decision Support System Module Implements the reorder point calculation

$$ROP = d \times L + S$$

where ROP is the reorder point, d is average demand rate, L is lead time, and S is stock level.

2.3. Convolutional Neural Network (CNN) Module

Utilizes a VGG-16 backbone for drug recognition via image scanning. The CNN extract features from drug packaging images and maps them to stored inventory items.

2.4. Graphical User Interface (GUI)

Provides managers with advisory messages on stock levels, visual analytics, and reorder recommendations.

The workflow begins with the CNN scanning and identifying a drug. The DSS retrieves stock and demand data, calculates the reorder point, and compares it with current stock. If stock ≤ ROP, a reorder advisory is issued.

2.5. Logic Flow Chart for the Dss

It was essential to consider the flowchart for the logic of the reorder point. The logic considered is as shown in Figure 1.

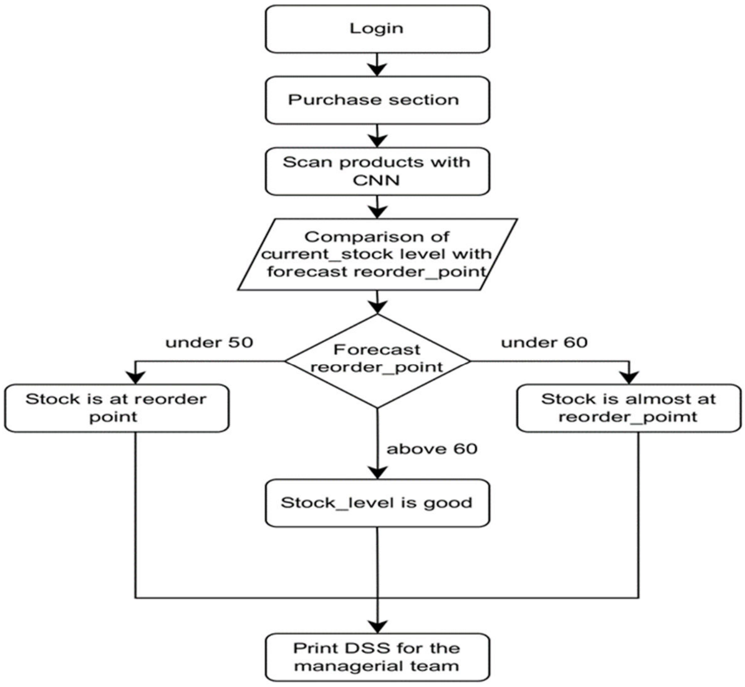

Figure 1. Flowchart illustrating two conditions — Left: when stock level is less than or equal to the reorder point; Right: when stock level is greater than the reorder point.

The system continuously compares stock levels with forecasted reorder points and generates advisory messages for the management team. A user-friendly interface with graphical dashboards facilitates interpretation of inventory data and decision-making.

3. RESULTS

The DSS was tested using pharmaceutical sales and inventory data. Sample products included Panadol, Amoxil, Zithromax, Cipro, Flagyl, Glucophage, and Aleve. Table 1 shows stock levels compared with calculated reorder points.

Table 1. Stock Levels and Reorder Points.

Product	Stock-In	Reorder Point
Panadol	50	40
Amoxil	80	48
Zithromax	120	60

Cipro	43	15
Flagyl	89	53
Glucophage	600	255
Aleve	300	220

The system successfully issued reorder alerts when stock levels approached or dropped below reorder points. Graphical outputs provided intuitive visualizations of inventory trends. Compared to manual methods, the DSS reduced stock-out incidents and minimized overstocking. Decision-making speed improved significantly, with reorder advisories generated in seconds instead of hours. Compared with barcode-based systems, which fail when barcodes are damaged or misaligned, the figure below shows the DSS result after the code has been tested.

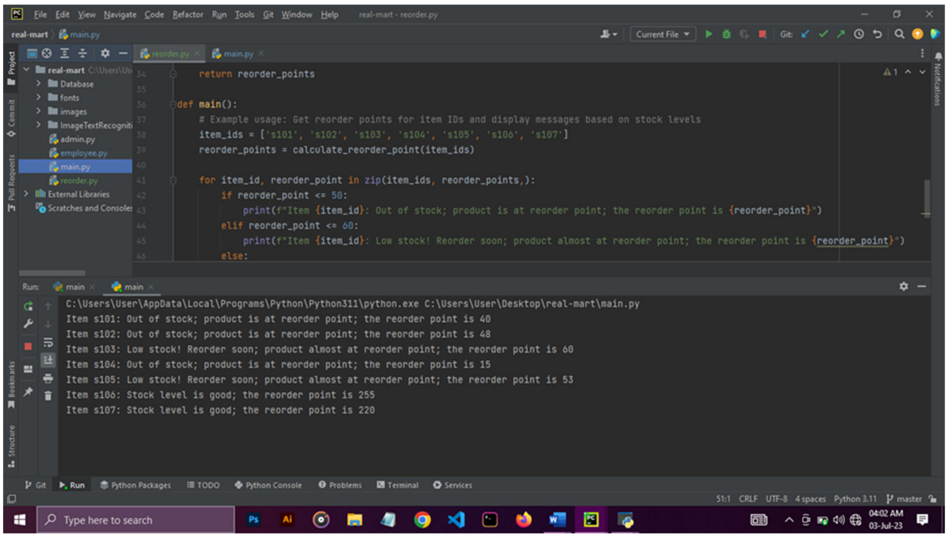

Figure 2. Summary of the Decision Support System result after applying the algorithm.

Figure 2 presents a summary of the Decision Support System (DSS) results after applying the reorder point algorithm to selected pharmaceutical products. The figure illustrates how the system evaluates current stock levels against calculated reorder points based on demand rate, lead time, and safety stock. Medicines with stock levels below or equal to their reorder points trigger an advisory notification, prompting timely replenishment, while those above the threshold are flagged as adequately stocked. This visual summary highlights the DSS capability to provide real-time insights, reduce stock-out risks, and optimize inventory decisions by ensuring that replenishment actions are data-driven and proactive.

4. DISCUSSION

The implementation of the proposed Decision Support System (DSS) demonstrates both the technical feasibility and the operational benefits of integrating intelligent decision tools into pharmaceutical inventory management. The developed application includes a functional inventory management interface consisting of a landing page, employee and administrator login modules, and a payment section. User authentication is verified against stored records in the database, ensuring secure access to system features.

The implementation of a Decision Support System (DSS) for pharmaceutical inventory management demonstrates the potential of combining classical inventory control principles with modern artificial intelligence techniques. The developed system integrates a landing page, login authentication for employees and administrators, and modules for payment and product tracking, which provide a functional interface for interaction. The authentication process ensures data integrity by allowing only registered users access, thereby securing sensitive inventory information. One of the core contributions of this work is the ability of the DSS to provide real-time reorder point recommendations. By leveraging average demand, lead time, and stock data, the system generates advisory messages that allow managers to make informed decisions and reduce the likelihood of stock-outs or overstocking. This capability aligns with prior studies that emphasize the importance of data-driven decision support in retail environments, but it further extends their application to pharmaceutical inventory where patient health outcomes are directly affected.

The database designed for the application currently supports CRUD operations, which validates its suitability for continuous updates as stock levels fluctuate. Although the database is still in a pre-production stage, its design provides a strong foundation for scaling into a live pharmacy setting. The CNN module, which is still undergoing dataset collection and training, represents another major advancement of this project. Once fully integrated, the CNN will enable the automatic recognition of medicines through image segmentation, eliminating dependency on barcodes, which are often damaged or misplaced. Similar studies in retail product recognition have shown the robustness of CNN-based approaches, and this research is expected to extend these findings to the pharmaceutical context. Despite the promising outcomes, the current system has limitations. The CNN module has not yet been fully trained and validated due to limited availability of pharmaceutical image datasets. Additionally, integration between the DSS and the pre-production database is still ongoing, which restricts full automation of decision-making. Nevertheless, these limitations present opportunities for future research. In practice, the adoption of such a DSS could significantly reduce operational inefficiencies, improve medicine availability, and enhance customer satisfaction. Beyond pharmacy operations, the framework can be extended to hospital supply chains, wholesale distribution, and other sensitive retail industries. Future work will focus.

5. CONCLUSION

The implementation of a Decision Support System (DSS) for inventory management in a pharmaceutical retail outlet offers significant benefits, such as optimized inventory levels, reduced stockouts, increased profitability, and streamlined management processes. The effectiveness of the DSS depends largely on the quality of the data used to develop the model and the accuracy of its recommendations. With proper training and support, it can become an essential tool for effective inventory control. However, due to time constraints, the DSS was not fully integrated with the inventory management database.

Future improvements should focus on completing this integration, generating comprehensive datasets for CNN training, deploying the system in real-world pharmacy environments, and incorporating advanced technologies such as IoT sensors and blockchain to enable real-time monitoring and ensure transparency.

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