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Optimizing inventory management and demand forecasting system using time series algorithm

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Abstract

In the rapidly evolving business landscape, effective inventory management and meeting customer demands rely heavily on accurate forecasting. While technology automates parts of inventory control, human expertise remains vital in decision-making for forecasting. Building supplier relationships, monitoring market trends, and adaptable supply chains are crucial too. Accurate demand forecasting reduces costs, streamlines operations, and boosts customer satisfaction. Therefore, companies must carefully review their forecasting methods to stay competitive. Researchers are addressing the lack of data on inventory and forecasting by focusing on implementing time series algorithms, recognizing their crucial role in optimizing these processes. This academic pursuit has led researchers to develop a user-friendly system tailored for improved inventory management, integrating a feature set dedicated to demand forecasting. The project aims to streamline user operations by offering an intuitive platform that facilitates seamless navigation. By encompassing forecasting capabilities, the system empowers businesses to accurately predict their future product requirements. The primary objective of this initiative is to simplify inventory procedures while enabling users to proactively meet upcoming demands effectively. While conducting the study, the researcher considered the first problem in how the user will use the inventory system in a more user-friendly manner. The second problem that the researchers conducted was manual input, and it will cost more when the documents are not organized. Lastly, the highest problem that the inventory management conducted was the overseers of the products by excessive inventory, low stocks, and expired products. The researchers use some of the sub-characteristics of ISO 25010 that are appropriate for evaluating inventory management. After evaluation, the sub-characteristics of functional stability garnered an overall weighted mean of 3.90. The compatibility and usability garnered an overall weight of 3.89. Reliability garnered an overall weight of 3.66. Lastly, maintainability was overall weighted at 3.63. The confusion matrix was used with the help of the tool of Weka Software using the scheme of function. Simple Logistics. The evaluation on the training set has a summary of correctly classified instances of 89.4737% and incorrectly classified instances of 10.5263%, which indicates that the application has an accurate algorithm.

Keywords: Inventory; Forecasting; Time-series; Supplies; Reorder Point

1. Introduction

Nowadays, business is hard and fast-paced, making it increasingly difficult to keep up with changing market conditions and customer demands. Advances in technology, such as machine learning and predictive analytics, have made it possible to automate some aspects of forecasting and streamline inventory management processes. However, technology alone cannot replace the human expertise and judgment needed to develop effective forecasts and make informed decisions about inventory. In short, while forecasting is a key component of inventory management,

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businesses must also invest in developing strong relationships with suppliers, monitoring market trends, and maintaining a nimble, responsive supply chain to succeed in today's fast-paced business environment.

Inventory management is the process of overseeing the flow of goods in and out of a company's warehouses and retail locations. Effective inventory management is essential for companies to maintain optimal levels of inventory to meet customer demand while minimizing costs associated with holding and storing inventory. Forecasting plays a critical role in inventory management as it helps companies anticipate future demand for their products and services. Forecasting involves analyzing historical sales data, market trends, and other relevant factors to predict future demand for a product.

Effective inventory management with accurate demand forecasting can help companies reduce costs, optimize operations, and improve customer satisfaction. The selection of the appropriate forecasting technique depends on a variety of factors, and companies must carefully evaluate their options to ensure that they are using the most effective method for their specific needs.

1.1. Statement of the problem

- Due to manual labor, the store needs to enhance its inventory management system to improve inventory visibility and optimize inventory turnover.
- The store is struggling due to inadequate demand prediction, leading to stockouts, excess inventory, and financial loss.
- The store is facing challenges in meeting customer preferences due to inefficient forecasting of seasonal demand resulting in slow inventory sales.
- Existing systems evaluate historical sales data and inventory levels to assess product demand and optimize stock replenishment based on past trends and business rules.

1.2. Objectives of the study

1.2.1. General Objectives

The general objective of this study is to address issues with inaccurate demand prediction and inadequate inventory management and to improve forecasting accuracy, reduce costs, enhance customer satisfaction, and optimize inventory levels for efficiency and profitability.

1.2.2. Specific Objectives

1. To establish an inventory monitoring system with a control dashboard to help improve inventory visibility and track inventory levels, turnover.

    - Login authorization
    - Suppliers, employees, and products information
    - User-friendly interface

2. To set up a system for automatic inventory forecasting models that uses real-time inventory monitoring to predict future demand for products.

    - Automatically highlight low stock levels and prevent excessive inventory
    - Stock aging tracking to determine how long the inventory has been in stock
    - Automatic disposal of expired products

3. Implement an inventory feature that uses forecasting to improve the accuracy of demand forecasting by using time series and algorithm techniques.

    - Generate predictions of future demand for products every monthly and yearly
    - Generate and export purchase order
    - Options to generate and export inventory reports in different file formats

4. To test and evaluate the developed system using ISO 25010 standards to enhance demand forecasting accuracy, minimize stockouts and overstock, reduce costs, and ensure scalability and adaptability to changing market conditions.

1.3. Scope

The system will be designed to support forecasting techniques for inventory management. It will enable businesses to predict demand for their products, forecast future inventory levels, and generate purchase orders. The system will support various forecasting methods such as time series. The system will enable businesses to track their inventory levels efficiently. It will allow users to create and manage inventory items, monitor product movement, and set reorder points. It will allow users to generate reports on inventory levels, product movement, and stockouts.

1.4. Delimitation

The system will not be responsible for physical movements of inventory, such as shipping and receiving, or the management of warehouse operations. It will not include features for managing other aspects of business operations, such as accounting, customer relationship management, or human resources management. Additionally, the system will not offer any physical inventory management capabilities, such as barcode scanning or RFID tracking. The system will not make decisions on behalf of the business regarding inventory management or purchasing. It will provide data and recommendations, but ultimately, the business owner or manager will be responsible for making decisions. The system will also not include features for managing supply chain relationships or supplier information.

2. Methodology

2.1. Conceptual Framework

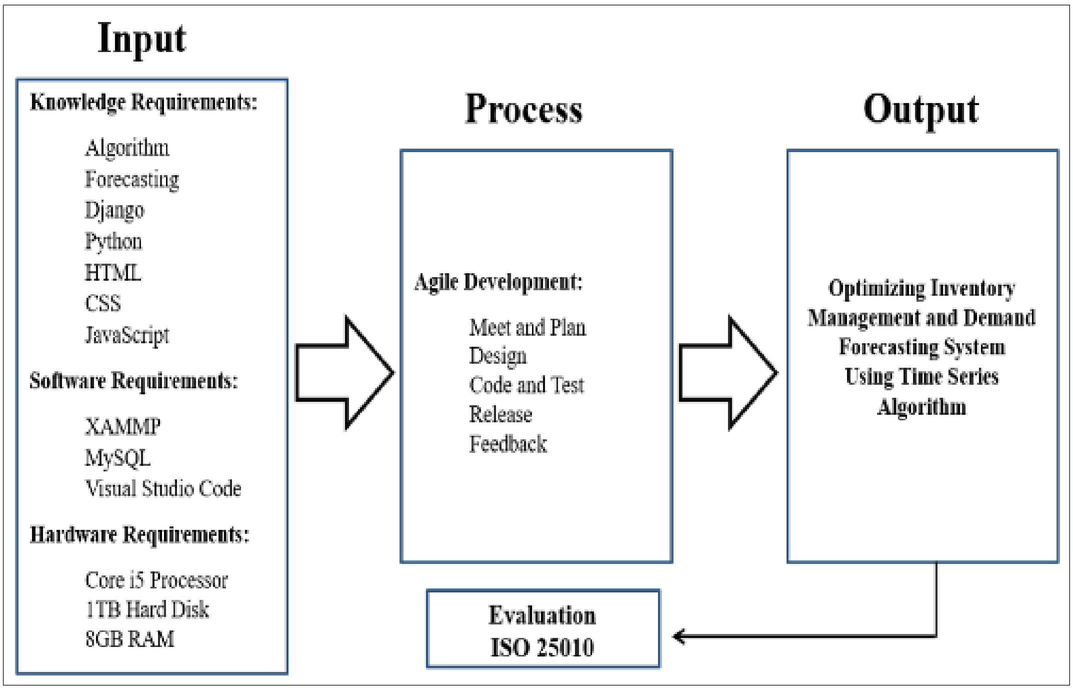

Figure 1 Conceptual Model of the System

Figure 2 shows the input, process, and output. The input must contain such things as knowledge, software, and hardware requirements. Knowledge Requirements is the key to the development of the system Software Requirements are the applications that should be used during the development of the system, Hardware Requirements are the physical components of the device to run the system smoothly. During the process the system will undergo agile development, such as meet and plan, design, code and test, release, and feedback. Lastly is the output, the system will be published or released to use by the user.

2.2. System Development

Figure 3 illustrates the entire process, incorporating an Agile development process involving analyzing user requirements, designing a program with flexibility for future changes, coding incrementally, documenting and testing the system, and maintaining it. This approach emphasizes collaboration with clients and stakeholders, allowing for continuous integration and testing. The system is then operational, ensuring its functionality and continuous improvement. By adopting Agile principles, the team aims to deliver a high-quality system that meets evolving needs.

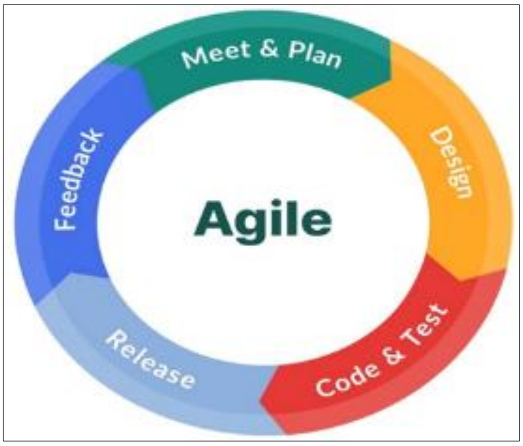

Figure 2 System Development Life Cycle

2.3. Instrument Used

The researchers utilized a survey interview as the primary instrument to gather data and insights from participants regarding inventory management and forecasting. The survey interview was thoughtfully designed to include a structured set of questions specifically aimed at exploring various aspects of inventory management and forecasting practices. Through this instrument, the researchers were able to obtain valuable data from a diverse pool of respondents, shedding light on their experiences, perspectives, and strategies related to inventory management and forecasting. The survey interview facilitated the gathering of detailed information, opinions, and perspectives on the challenges, strategies, and best practices associated with inventory management and forecasting. Overall, the survey interview proved to be an effective tool for gathering crucial insights into inventory management and forecasting, enhancing the researchers' contribution to the existing body of knowledge in this area.

3. Results

The researchers used ISO 25010 as a complete framework for quantifying and evaluating the inventory management system. To determine the system's capabilities, comprehend the user response, and collect useful information from the respondents for the system's improvement, the researchers conducted a project review. The researchers deploy a paper survey as well as an online survey using Google Forms. Fifty (50) people have responded. Twenty-nine (29) people responded in a paper survey and Sixteen (16) people responded to an online survey via Google Form. To test the system, five (5) indicators were available.

3.1. Functional Suitability Overall Weighted Mean: 3.91

- Functional Completeness: 3.80
- Functional Correctness: 3.90
- Functional Appropriateness: 4.02

3.2. Compatibility Overall Weighted Mean: 3.89

- Co – Existence: 3.92
- Interoperability: 3.86

3.3. Usability Overall Weighted Mean: 3.89

- Appropriateness Recognizability: 4.06
- Learnability: 3.82
- Operability: 3.96
- User Error Protection: 3.62
- User Interface Aesthetics: 4.10
- Accessibility: 3.78

3.4. Reliability Overall Weighted Mean: 3.66

- Maturity: 3.72
- Availability: 4.00
- Fault Tolerance: 3.26

3.5. Maintainability Overall Weighted Mean: 3.63

- Modularity: 3.80
- Reusability: 3.76
- Analyzability: 3.48
- Modifiability: 3.58
- Testability: 3.54

3.6. Evaluation

Table 1 Evaluation ISO 25010

EVALUATION (ISO 25010)							
Functional Stability	**P**	**F**	**G**	**VG**	**E**	**Sub - Characteristics**	**Overall Weighted Mean**
Q1	1	2	11	28	8	Functional Completeness	**3.91**
Q2	2	0	10	27	11	Functional Correctness	
Q3	2	1	7	24	16	Functional Appropriateness	
Compatibility	**P**	**F**	**G**	**VG**	**E**	**Sub - Characteristics**	**Overall Weighted Mean**
Q4	1	0	13	24	12	Co – Existence	**3.89**
Q5	1	2	11	25	11	Interoperability	
Usability	**P**	**F**	**G**	**VG**	**E**	**Sub - Characteristics**	**Overall Weighted Mean**
Q6	0	1	12	20	17	Appropriateness Recognizability	**3.89**
Q7	0	1	17	22	10	Learnability	
Q8	1	0	15	18	16	Operability	
Q9	0	4	17	23	6	User Error Protection	
Q10	0	3	8	20	19	User Interface Aesthetics	
Q11	0	2	15	25	8	Accessibility	
Reliability	**P**	**F**	**G**	**VG**	**E**	**Sub - Characteristics**	**Overall Weighted Mean**
Q12	1	2	17	20	10	Maturity	**3.66**
Q13	1	2	8	24	15	Availability	
Q14	5	5	18	16	6	Fault Tolerance	
Maintainability	**P**	**F**	**G**	**VG**	**E**	**Sub - Characteristics**	**Overall Weighted Mean**
Q15	1	5	9	23	12	Modularity	**3.63**
Q16	2	5	9	21	13	Reusability	
Q17	4	5	13	19	9	Analyzability	
Q18	2	7	12	18	11	Modifiability	
Q19	4	4	15	15	12	Testability	

It shows how effective and efficient when the respondent's uses the system.

3.7. Confusion Matrix

```
=== Summary ===

Correctly Classified Instances          17               89.4737 %
Incorrectly Classified Instances         2               10.5263 %
Kappa statistic                          0.6122
Mean absolute error                      0.2718
Root mean squared error                  0.3101
Relative absolute error                 78.0266 %
Root relative squared error             75.881  %
Total Number of Instances               19
Ignored Class Unknown Instances                 31

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 1.000    0.500    0.882      1.000    0.938      0.664    0.587     0.664     Good
                 0.500    0.000    1.000      0.500    0.667      0.664    1.000     1.000     Very Good
Weighted Avg.    0.895    0.395    0.907      0.895    0.880      0.664    0.674     0.735

=== Confusion Matrix ===

  a  b   <-- classified as
 15  0 |  a = Good
  2  2 |  b = Very Good
```

Figure 3 Confusion Matrix

4. Discussion

Providing an easy-to-use inventory management system with the ability to apply time-series technique forecasting is the main goal of this project. The researchers discovered the benefits and drawbacks of creating an inventory management procedure through this research. The researchers set out to give users a safe and efficient method using demand forecasting and time series algorithms that can be useful for inventory management, as it can help to forecast the future demand for products or services and adjust the inventory levels accordingly. By using time series analysis, inventory managers can avoid overstocking or understocking, and improve customer satisfaction and profitability. Despite its apparent simplicity, it is the method by which items are tracked along the whole supply chain, from purchase through manufacturing to final sales. It is important to forecast because it can help to reduce inventory costs, meet customer demand, and improve workflow efficiency using an online website. It is a system that can deliver the required outcomes in the future and provide users with streamlined, and well-organized data that can help them save time and effort. The researchers decided to take advantage of the opportunity to fully utilize the potential of the inventory management system.

For future researchers, after the development of the system has been effective, there is always room for improvement. The researchers would like to suggest that in order to make the system even better, it should be improved further by incorporating auto-generated reports or product sorting's that are more convenient and adaptable, in line with current trends. This technology has the power to significantly increase productivity and reduce user burdens. These recommendations are meant to help future researchers make sure their own research is accurate and valuable by using this study as a reference.

5. Conclusion

In conclusion, even though the evaluation's results indicate that the system's failure tolerance is not particularly great, the researchers can still conclude that the system's user interface aesthetics were accurate and safe. Moreover, among all the results, the system's recognizability comes in second. Furthermore, the system is adaptable and will continue to function even in the event of changes. It is known to the researchers that users can still utilize the system despite its flaws. The researchers set up an inventory monitoring system with a controllable dashboard and improved interface to help track inventory levels, log-in authorization, supplier, employee, and product information and improve inventory visibility. In some ways, the system was in line with the first intended objective. In addition, with regard to objective 2, the researchers put in place a system for automatic inventory forecasting models that make use of real-time inventory monitoring to forecast future demand for products. These models include the following features: automatic expiration of products; stock aging tracking to ascertain how long a product has been in stock; automatic highlighting of low stock levels; and prevention of excessive inventory. Additionally, the researchers implemented an inventory feature that makes use of time series and algorithmic techniques to forecast demand more accurately. Users will also be able to generate predictions of future product demand on a monthly and annual basis, generate and export purchase orders, and generate inventory reports in a variety of file formats, including CSV, JSON, and XLS. Lastly, in order to accurately assess user satisfaction with time-series algorithm-based demand forecasting and inventory management systems, the researchers employed a survey as part of Objective 4. The researchers employed ISO 25010 as their evaluation methodology.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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