AI-Powered Inventory Management System for Small Retail Business

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12/12/2024

1. Problem Statement

Today's retail environment has revealed that inadequate control of inventory continues to be a problematic issue affecting most SMEs. Inadequate bar code tracking and withdraws many small businesses still follow manual tracking or ineffective inventory tracking software solutions and it typically results in stock out, more stock in, slow replenishment and missed sales. These inefficiencies are caused by:

- The inability to keep track of inventory in real-time.
- Demand forecasted is often inaccurate.

There is little coordination between the sales data and related restocking of inventory. Consequently, an automated system of managing inventory employs the use of machine learning algorithms to evaluate the need for certain inventories and employ actual-time data that will help in forming a better inventory pool. It eliminates or minimizes the chances of making mistakes and the stockouts/overstock issues, in addition to improving the working of retail shops that are small-scale.

The primary goal will be a resolution of the issues relating to inventory for small and medium retail businesses using machine learning recommendation systems.

2. Market/Customer/Business need Assessment

Market Overview

The retail business sector, especially SMEs are having a lot of issues in managing the stock. As the number of competitors increases and the focus on the needs of the customer, small retailers still must have ways to minimize stock levels and expenses. But the reality is still uplifting that many SME's are using traditional or manual methods of inventory control that causes inefficiencies.

2.1 Challenges Faced by SMEs

- **Manual Inventory Tracking:**
  Owners of small businesses typically employ basic excel spread sheets or basic POS without real-time data tracking; inventory is skewed.

- **Stockouts and Overstock Issues:**
  This research also confirmed that inaccurate demand forecasting leads to overstocking or stockouts which in turn causes revenue losses and low satisfaction of the customers.

- **Inefficient Supply Chain Integration:**
  When the sales data is not integrated together with supplier data, and inventory system, small businesses are unable to achieve an adequate inventory stock level.

2.2 Customer Needs

- **Real-time Inventory Visibility:** Many business entities desire to monitor stock in real-time in order to avoid uncomplicated problems such as stockouts and overstock.
- **Predictive Demand Forecasting:** There is hence a call for systems to help SMEs forecast future demand from sales as they work on determining inventory stock levels.
- **Affordable & Scalable Solutions**: Due to the pressure on the SME's core business and possibly limited budget, the type of AI solution is best that is not expensive and can easily integrated with existing systems.

2.3 Business Need Assessment

Small retailers need technologies that assist in decision making and enable them to organise their stocks in the best way possible. These businesses want solutions that offer:

- **Automated Insights:** When used on live databases as a means of guiding stock control.
- **Reduced Manual Effort:** Minimizing time and costs through automation of ordinary inventory operations.
- **Improved Accuracy:** Accurate stock predictions to reduce food wastage, in order to achieve high returns on investment.

2.4 Target Market

This product targets:

- **Grocery Stores**
- **Clothing Boutiques**
- **Local Food Chains**
- **Small Convenience Stores**

3. Target Specification and Characterization

The main purpose of the AI-Powered Inventory Management System for Small Retail Businesses is to offer small and medium enterprises an easy to use, customizable, and effective solution. To this end, several properties of the resulting targets for the number are specified below.

3.1 Key Specifications

- **Real-Time Inventory Tracking**
  Allows businesses to keep updating the status of stocks as they are given a real-time view of their inventories. Whenever the stock level is below or above certain pegged values, alerts are produced.

- **Demand Forecasting**
  Relies on past information of sales data coupled with statistical forecasting to determine future inventory requirements well. Uses machine learning algorithms in the identification of these moves and fluctuations in customer traffic.
- **User-Friendly Interface**
  The work-flow has been kept as simple as possible, so that non-technical staff would not need much training in its operation. For easy retrieval and for the convenience of the owners where inventory can be done through web and mobile.
- **Automation and Integration**
  Manages work flow of day to day operational activities like inventory reordering, supplier records, and purchase order. It interfaces perfectly with existing POS, accounting system as well as API of various suppliers.
- **Cost-Effectiveness**
  It offers a wide solution and guarantees that SMEs of different categories will be able to implement it with reasonable costs.

3.2 The Targeted Users

- **Business Size:**
  The small and medium-sized retailers who have a weak technical background and have strict financial control.
- **Business Type:**
  Consists of supermarkets, convenience stores and rural stores, small traditional multiple stores, and neighbour-hood stores.
- **Experience Level:**
  They can be adopted for use by organizational owners and staff who may not possess technical skills, simplify, making the use of such systems manageable.

4. External Search

- https://www.ibm.com/artificial-intelligence?utm_content=SRCWW&p1=Search&p4=43700077827237093&p5=p&p9=58700008530962751&gclid=CjwKCAiAjeW6BhBAEiwAdKltMol3Bmiry-tODTWXgWn7clLD9MR1KC2KORRYithEVPxq66_6La3yRxoCz_sQAvD_BwE&gclsrc=aw.ds
- https://towardsdatascience.com/machine-learning-for-store-demand-forecasting-and-inventory-optimization-part-1-xgboost-vs-9952d8303b48
- https://mobidev.biz/blog/retail-demand-forecasting-with-machine-learning
- https://www.forbes.com/sites/allbusiness/2024/09/19/how-small-businesses-are-using-ai/

5. Benchmarking Alternate Products

Comparison with existing solutions

Product/Service	Features	Drawbacks for SME's
Traditional inventory systems.	Manual or semi-automated inventory tracking.	Costly, time-consuming and error prone.
Enterprise resource planning.	AI forecasting and real-time monitoring.	Expensive and complex for SME's.
AI-powered tools like Trade gecko.	AI demand forecasting and inventory tracking.	Subscription costs are unaffordable

6. Applicable Patents

Some machine learning frameworks (open source) could be employed. These frameworks and related models are publicly licensed, allowing integration into inventory use cases:

- TensorFlow for ML modeling.
- Scikit-learn for demand forecasting models.
- PyTorch for real-time tracking data insights.

7. Applicable Regulations

- GDPR - Creating customer data protection in retail analytics for customers.
- SC&L regulations concerning compliance with laws for the retail business.
- Restricted licensing policy agreements of the frameworks (TensorFlow, pytorch, sklearn).

8. Applicable Constraints

- **Budget:**
  SMBs are characterized by limited financial resources available for investment. It means that the cost of implementing the AI-based solution, ranging from the initial setup, the cost of hardware, including Internet of Things devices for inventory tracking, the subscription to the cloud services, to the maintenance should be moderate for the SMBs. This constraint can be addressed by implementing a flexi pricing model or providing packages of services that a firm can open incremental service layers with.
- **Team Expertise:**
  Small business owners and their staffs are not always IT literate, which becomes a barrier to adoption IST 205 Final Exam – Week 3 Importance of e-commerce Website

Development Truths and Trends Page 4 of 12 Chahal, J., & Shrivastava, R. The system must therefore be user friendly with a graphical user interface, capacity to use wizards, and unlimited customer support. Moreover, possibilities for language localization and support of regional languages can improve access of the application for different categories of users. Special training sessions may be dealt with on how to enhance the confidence and frequency of users when handling the developed programs or to make them aware of the availability of the training programs and workshops.

- **Technology Infrastructure:**
  A large proportion of small retailers and many of the poorer and remote regions may well have limited technological resources. Challenges to the setup include; poor and slow internet connection, old computers and hardware, and insufficient IT personnel. The solution should preferably be service based, where it can work in low connectivity environment, provide offline use or cached content.

9. Business Model

9.1 Monetization Strategy

- **AI Subscription Model:**
  The subscription model forms the backbone of the monetization strategy, providing steady revenue while offering value to businesses
- **Monthly Licensing Fee for AI Insights:**
  Companies provide steady subscription fees and it depends on how a business is sized. Tiers include featured or consumed based on limitations such as, the number of products that may be tracked and the number of features that can be used.

9.2 Feature Highlights

- **Real-Time Demand Prediction:** Sales trends are predicted by the AI algorithms to allow accurate stock purchases.
- **Inventory Alerts:** Message alerts for; items that are running low in stock, items which are over stocked or items that are nearing their expiry date.
- **Sales Trends Analysis:** AI regulation of customer buying habits to enable organizations buy appropriate kinds of products to be stocked.
- **Automated Restocking Recommendations:** It also fits into supplier systems that give it real-time procurement recommendations.
- **Premium Add-Ons:** These and other features, including multi-site inventory tracking or else an API connectivity for integration with third-party programs, are available at a premium.

9.3 Custom Analysis Services

Small and medium enterprises (SMEs) often face unique challenges, and custom-tailored AI solutions provide a way to address these while generating additional revenue:

- **Bespoke AI Insights:**
  Offer reports based on the exact general field that the customer is operating or the particular business issues affecting the organization.
  For instance, suggestions from models may involve space utilization during holidays or months with a large number of visitors, for instance, festivals or low priced products promotions.
- **One-Time or Recurring Projects:**
  Sell one or more specific analyses or continuous customized data services to the business.
  Services could include predicting the sales in those periodic product releases or loss-making stocks in the store.
- **Dedicated Support and Consultation:**
  Show your clients how to incorporate AI tools in their platform with the help of professional consulting at hourly or per-project rates.

9.4 Freemium Model

This model is designed to attract a wide audience and convert free users into paying customers by demonstrating value upfront:

- **Free Basic Insights:**
  Provide only a few capabilities for free, basic inventory management, and simple kind of alerts. Provide people with an opportunity to navigate and check out the application with its possible advantages.

9.5 Premium Features on Subscription

The features like advanced analytics, sales forecasting and business reports come with an added cost.
Commercial editions are simpler to explain as this offers the user an organized upgrade path as their business expands or changes.

- **In-App Purchases:**
  To address this, other or more data (e.g., previous trends, advanced datasets) can be bought by free users using our API.
- **Upselling Opportunities:**
  Please offer add-ons to free users through use of adverts or even give them taste of paid services so that they can be convinced to upgrade to a premium account.

10. Concept Generation

- **Demand Prediction for Seasonal Inventory Replenishment:**
  The idea concerns use of machine learning algorithms in estimation of seasonal demand for inventory restocking. Through the implementation of the system, the organization can be capable of estimating accurate demands from the flow of historical sales data, markets, and external conditions such as; holidays, and weather. This helps in averting oversupply of certain products to and low supply or lack of some of these good in certain seasons, hence helping business people maintain an optimum stock.
- **Data Visualization Dashboards:**
  By day, info-graphics real time and visual interactive dashboards offer information on current stock situation. These dashboards contain important information that includes the stock status, rate of turnover, and reorder point among many others. Business people such as business owners and managers are able to easily track the health of their inventory making it Easy for quick decisions to be made without the need for a professional in the area.
- **AI Model for Pattern Detection:**
  An AI upgrades current data with the past sales data to find trends to help in restocking. This is in line with the identification of cyclic patterns of sales, that is explaining what products sell well at what time, and identifying products that may take some promotional campaigns to shift off the shelves.
- **Automated Reorder Triggers:**
  Reorder activities will also be managed automatically at various level based on recommended quantities. This would alert the system to automatically restock when certain bounds of inventory are creep closer so that the stock will not run out yet it had reached the replenishment limits.
- **Supplier Integration:**
  Good supplier interface mean that they can communicate with the inventory directly and without interference. They basically eliminate some of the many procurements one has to make thus minimizing errors when it comes to stocking.

11. Concept Development

The AI-Powered Inventory Management System for Small Retail Business is intended to optimize the inventory function by using histogram and curve analysis and forecast real-time models. The idea is based on offering a single-sourced solution which involves demand forecasting, stock improvement, and active inventory management.

It also becomes clear that the system will complement current functioning of existing retail businesses of small owners and track inventories. To enhance the order fulfilment, the system will consider the past sales data, current market conditions together with predictive demand analysis, for optimal re-ordering the inventories and for managing the orders.

Key features will include:

- **Real-time Inventory Tracking:** Tracking the stock levels with possibilities for automatic updates and messages.
- **Demand Forecasting:** Forecasts of future demand as influenced by past sales data, changes in the market and shifting seasonal trends.
- **Automated Reorder Suggestions:** Presenting the user with suggested reorder quantities based on consumption, inventory and availability time.
- **Customizable Dashboards:** Creating interfaces that enable the business owner to interact with critical input data holdings in a graphical, consumable fashion.
- **Integration with External Systems:** Enabling integration with POS systems, and accounts as well as other business solutions for a smooth running of operations.

12. Final Product Prototype

The AI-Powered Inventory Management System as a proposed system intended for retail businesses, especially those that are small and medium sized. This way and through the help of sophisticated AI algorithms it prognoses the future demand, identify outliers and adjust inventory stock in real-time. This supports organizations' existing point of sale (POS) system and delivers intelligence in an easy to assimilate web based graphical interface.

The proposed system consists of three key modules: The three core competencies include Data Integration, AI Analytics, and User Interface (UI). The workflow starts with the data input stage, where the system either automatically retrieves data from POS systems, supplier databases or when manually fed to the system. This is then cleansed, transformed and analysed by the AI module to generate insights about itself for it to take corrective actions. The findings are presented on a dashboard that is available on the web and/or mobile interfaces.

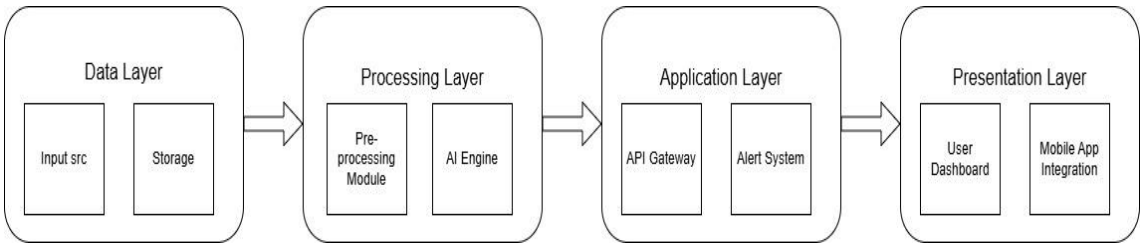
12.1 Key Features:

- **Demand Forecasting:** Through machine learning solutions, it designs a Mathematical model that helps in the prediction of future requirements of stocks and results in timely restocking.
- **Stock Categorization:** It works on low volume-high demand and high volume-low demand product velocity and profitability.
- **Anomaly Detection:** Discovers dysfunctional trends like; sales increases or decrease in the number of existing stocks.
- **Real-Time Alerts:** Alerts for low stock and other inventory issues, and also alerts when restocking quickly is necessary.
- **Data Visualization:** Allows one to quickly and easily generate substantive reports and charts of any chosen type.

- **Customizable Insights:** Provides personalized suggestions in regard to certain company objectives or limitations.

12.2 Schematic Diagram

The system's architecture is divided into several interconnected layers:



- **Data Layer:**
  Input Sources: Customers' and suppliers' database, sales and purchases record, inventory files.
  Storage: Database to be set up on the cloud so that historical and real pieces of information can be kept and retrieved at the real-time.

- **Processing Layer:**
  Pre-processing Module: This sections cleans and normalizes the input data.
  AI Engine: Uses algorithms for demand forecast, clustering and anomaly detection.

- **Application Layer:**
  API Gateway: Serves as an interface between back end AI models and front end dashboard.
  Alert System: Sends messages based on the defined limits.

- **Presentation Layer:**
  User Dashboard: Offers thoughts, graphs, and tables on a device-independent web page.
  Mobile App Integration: Enables them to obtain inventory information on the move.

12.3 Detailed Steps:

- **Data Collection:**
  Data that are entered via POS systems or are uploaded manually are received and stored on cloud database.
- **Data Analysis:**
  The AI module performs analysis on the data, then estimates the demand and find out any inconsistencies.
- **Insights Delivery:**
  The insights that are processed are then displayed on the dashboard.

- **Actionable Alerts:**
  The system uses notification to the business owners for immediate action like restocking or promotional changes.
  This prototype guarantees that small businesses can conveniently get information that will help rectify many wastes, boost profitability and increase efficiency.

13. Product Details

13.1 How Does It Work?

- Take data from POS systems in real time.
- However, the data undergoes some processing in the ML model in order to identify trends.
- These insights are summarized and presented in the form of an AI dashboard for the purpose of restocking alerts.

13.2 Data Sources:

- Sales data from POS systems.
- Historical demand patterns.
- Rising and falling seasons of purchase among consumers.

13.3 Frameworks/Algorithms:

- Scikit-learn for machine learning modeling (demand prediction).
- TensorFlow for handling real-time stream of consumptions data involving sales.
- Real time data visualization using Streamlit.

13.4 Required Team:

- Experts in Data Science who know and understand Machine Learning modes.
- People who know some web frameworks like streamlit.
- Developers who are familiar with the AWS and DevOps tools

14. Code Implementation

```
[1] import pandas as pd
    import numpy as np
    from prophet import Prophet
    import matplotlib.pyplot as plt

    # 1. Load your historical inventory data (for simplicity, we use random data here)
    # Assume we have daily sales data for the last 2 years
    date_rng = pd.date_range(start='2022-01-01', end='2023-12-31', freq='D')
    sales_data = np.random.randint(100, 500, size=(len(date_rng),))  # Simulated sales data
```

```
[2] # Create a DataFrame with date and sales data
    data = pd.DataFrame({'ds': date_rng, 'y': sales_data})
```

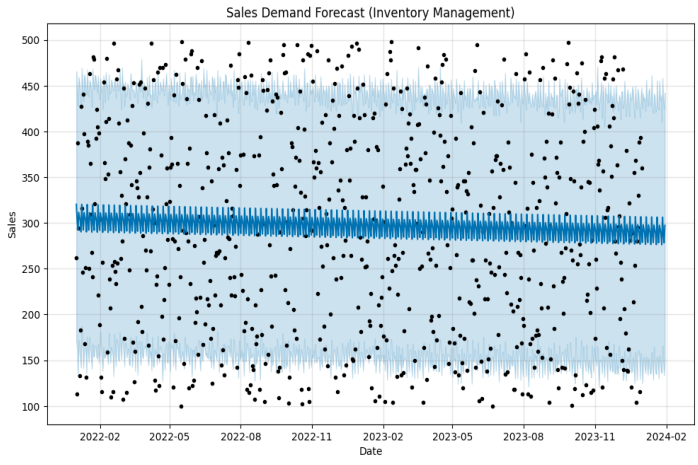
```
[3] # 2. Prepare the data for Prophet model (Prophet expects columns 'ds' for date and 'y' for the target)
    # This is the structure Prophet needs, so make sure to format it correctly

    # 3. Train Prophet model for demand forecasting
    model = Prophet()
    model.fit(data)
```

```
INFO:prophet:Disabling yearly seasonality. Run prophet with yearly_seasonality=True to override this.
INFO:prophet:Disabling daily seasonality. Run prophet with daily_seasonality=True to override this.
DEBUG:cmdstanpy:input tempfile: /tmp/tmp13xfholc/019g08zo.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp13xfholc/d6qrqt20.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.10/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=3307', 'data', 'file=/tmp/tmp13xfholc/019g08zo.json', 'ir
08:29:27 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
08:29:27 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
<prophet.forecaster.Prophet at 0x7c6261ab3f10>
```

```
[4] # 4. Make future predictions (let's predict for the next 30 days)
    future = model.make_future_dataframe(periods=30)
    forecast = model.predict(future)
```

```
[5] # 5. Visualize the forecast
    fig = model.plot(forecast)
    plt.title('Sales Demand Forecast (Inventory Management)')
    plt.xlabel('Date')
    plt.ylabel('Sales')
    plt.show()
```




```
[6] # 6. Calculate optimal inventory levels for the next 30 days based on forecasted demand
    forecasted_demand = forecast[['ds', 'yhat']].tail(30)  # Predicted demand for the next 30 days
```

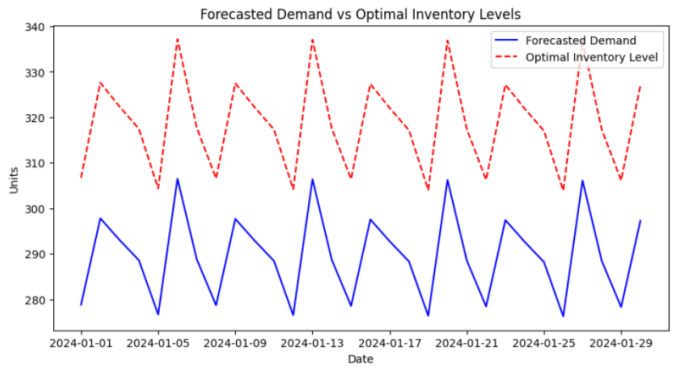
```
[7] # Assuming a simple replenishment rule: keep a safety stock of 10% of the predicted demand
    safety_stock = 0.10 * forecasted_demand['yhat']
```

```
[8] # Calculate the required inventory level (predicted demand + safety stock)
    forecasted_demand['optimal_inventory'] = forecasted_demand['yhat'] + safety_stock
```

```
[9] # Show the forecasted demand and calculated optimal inventory levels
    print(forecasted_demand[['ds', 'yhat', 'optimal_inventory']])
```

```
           ds        yhat  optimal_inventory
730 2024-01-01  278.838662         306.722529
731 2024-01-02  297.817845         327.599630
732 2024-01-03  293.036175         322.339792
733 2024-01-04  288.600673         317.460740
734 2024-01-05  276.674406         304.341847
735 2024-01-06  306.514034         337.165437
736 2024-01-07  288.815164         317.696680
737 2024-01-08  278.707627         306.578389
738 2024-01-09  297.686810         327.455491
739 2024-01-10  292.905139         322.195653
740 2024-01-11  288.469637         317.316601
741 2024-01-12  276.543371         304.197708
742 2024-01-13  306.382998         337.021298
743 2024-01-14  288.684128         317.552541
744 2024-01-15  278.576591         306.434250
745 2024-01-16  297.555774         327.311351
746 2024-01-17  292.774103         322.051513
747 2024-01-18  288.338601         317.172461
748 2024-01-19  276.412335         304.053568
749 2024-01-20  306.251962         336.877158
750 2024-01-21  288.553092         317.408402
751 2024-01-22  278.445555         306.290110
752 2024-01-23  297.424738         327.167212
753 2024-01-24  292.643067         321.907374
754 2024-01-25  288.207566         317.028322
755 2024-01-26  276.281299         303.909429
756 2024-01-27  306.120926         336.733019
757 2024-01-28  288.422057         317.264262
758 2024-01-29  278.314519         306.145971
759 2024-01-30  297.293702         327.023072
```

```
[10] # Optional: Visualize the forecasted demand and optimal inventory levels
     plt.figure(figsize=(10, 5))
     plt.plot(forecasted_demand['ds'], forecasted_demand['yhat'], label='Forecasted Demand', color='blue')
     plt.plot(forecasted_demand['ds'], forecasted_demand['optimal_inventory'], label='Optimal Inventory Level', color='red', linestyle='--')
     plt.title('Forecasted Demand vs Optimal Inventory Levels')
     plt.xlabel('Date')
     plt.ylabel('Units')
     plt.legend()
     plt.show()
```



I have implemented till the basic data frames, prophet model, visualization, forecasting and the calculations required to get to the resultant of the **AI-Powered Inventory Management System for the Small Retail Business.**

Below is the Google Colab link for the code:
https://colab.research.google.com/drive/1-X-0HzPMAqYwg-bq4bnSAmEWvQrQPZGB?usp=sharing

15. Conclusion

The AI-Powered Inventory Management System for Small Retail Businesses will optimize inventory, minimize stockouts, and maximize profitability for SMEs by leveraging machine learning insights. This system will provide SMEs with actionable demand forecasts and inventory alerts at a minimal cost, using advanced AI models in a scalable and cost-effective way.