Inventory Management With Machine Learning

Nileshkumar Mandal

21/09/2022

Abstract - "Inventory is the supply of raw materials, partially finished goods called work-in-progress and finished goods, an organization maintains to meet its operational needs. It represents a sizeable investment and a potential source of waste that needs to be carefully controlled. Inventory is defined as a stock of goods that is maintained by a business in anticipation of some future demand". Inventory management is a major requirement even for the small and medium shop owners. A system which tracks inventory levels, orders and sales in order to perform predictive analysis, obtaining forecasted demand will help to reduce over-stock and out of-stock situations. A good inventory management system must ensure keeping enough stock in the warehouse to ensure the business keep functioning but not enough stock to drain its limited cash reserves. This is a task where all business needs are to be anticipated, most of the calls made are crisis calls, yet where the people in-charge of the inventory need to find a solution. All done while simultaneously not using all the capital into non-moving stock." Forecasting product demand is one of the core challenges in any retail business ". Another question that needs to be answered is how we plan on using artificial intelligence into inventory management. Does it have any use in managing inventory? Artificial intelligence needs to be teamed with human oversight and should be treated as part of the system but not as a replacement for the system or the system itself. That being said, there are several companies that are using artificial intelligence in the inventory process and it is yielding very impressive results which leads us to believe that artificial intelligence might after all have a significant impact on demand forecasting. We are transitioning from the traditional ways of managing inventory, which is the direct result of the availability of the huge amounts of real-time data that are now routinely generated on the internet and through the interconnected world of enterprise software systems and smart products. Amazon, one of the giants in the business have used inventory management teamed with artificial intelligence in almost every part of the prediction process. "Optimum inventory should be maintained by all organization so that under inventory can be eliminated which disrupt the financial figures. Careful evaluation of internal and external factors through better planning can improve the status of inventory ".

Introduction:

Inventory plays a key role in every retail and e-commerce company. This aspect of running a trading business significantly influences cash flow, financial performance, and growth possibilities. That's why more and more retail and e-commerce companies decide to opt for inventory management using machine learning. What are the benefits of such a solution? And why can we say that inventory management using machine learning is definitely this industry's future? Let's find out!

Inventory management is a complex and difficult task, especially for companies operating more than one warehouse and stores selling thousands of products per month. Retail/e-commerce companies frequently struggle with order mix-ups, dead stock issues, insufficient stock levels, and warehouse disorder. On top of that, the human factor can also be a source of problems. Even if your WMS (Warehouse Management System) works correctly, your warehouse staff can, for example, put a given product on the wrong shelf. Such an initially unnoticeable mistake can lead to severe consequences, just to mention order mix-ups. If you run a retail company or an online store, we believe that inventory management using machine learning is an answer to your problems. In this article, we are going to show you how inventory management using machine learning can improve your business.

The concept of inventory management includes a vast set of areas to be dealt with. With the rapid expansion of e-commerce industry, the demand for efficient inventory management is the need of the hour. More research effort is required to improvise the existing inventory management techniques. E-commerce giants define an end-to-end machine learning system using probabilistic demand forecasting models that is built on Apache Spark. Such e-commerce giants contain large datasets. Forecasting usually includes two different methodologies: Time series methodology and Machine learning methods.

A case study of Inventory Management focused on identification of factors that influences inventory optimization among SMEs in steel sector through a structured and unstructured questionnaire can aid in effective inventory management. It involves grouping the factors into two sets as internal variables and external variables. Artificial neural networks (ANN) is an intelligent system that uses layers of neurons. ANNs are very good with fitting problems. A retrospective study on ANN for inventory management is required to improve prediction accuracy.

AI proves to be beneficial in handling the customer data and forecasting the purchase behaviour of customers AI can be used to provide notification when a company has to re-order stock and

assist in creating manufacturing schedule considering the variations in demand including seasonal increases accurately. A decision support system (DSS) is another technique that could be used to assist for effective monitoring of inventory levels and to ensure continuous availability. To perform inventory analysis that consists of multiple attributes under consideration, a hybrid methodology that integrates multi-criteria decision making (MCDM) techniques with different machine learning algorithms are used. The methodology uses ABC analyses for determining classes and Artificial Neural Network (ANN), Bayesian network, and Support Vector Machine (SVM) algorithms to predict different classes for inventory items.

Identification of dead inventory can be achieved by predictive modelling. Predictive modelling is a methodology in which a predictive algorithm predicts part obsolescence in advance with reasonable accuracy.

ABC analyses is a classification technique that determines the relevant classes for each of the inventory items, thus providing the proper foundation for demand forecast process. ABC analyses generates an optimized inventory stock classification.

The demand forecasting technique can be modeled by artificial intelligence approaches using artificial neural networks. Algorithms used for training such models include Batch gradient descent and Variable learning rate.

Software agents are multiagent systems developed within the JADE platform. Agents communicate through message exchange. The system is proposed to make the transition from the manual approach of inventory management software to a completely automated process.

1. Problem Statement:

A major requirement for small/medium-sized businesses is Inventory Management since a lot of money and skilled labour has to be invested to do so. E-commerce giants use Machine Learning models to maintain their inventory based on demand for a particular item. Inventory Management can be extended as a service to small/medium sized businesses to improve their sales and predict the demand of various products. Demand forecasting is a crucial part of all businesses and brings up the following question: How much stock of an item should a company/business keep to meet the demands, i.e., what should the predicted demand of a product be? We discuss the challenges of building an Inventory system and discuss the design decisions.

2. Market/Customer/Business Need Assessment:

One of the most valuable assets of a company is its inventory. In various industries, such as retail, food services, and manufacturing, a lack of inventory can have detrimental effects. Aside from being a liability, inventory can also be considered a risk. It can be prone to theft, damage, and spoilage. Having a large inventory can also lead to a reduction in sales.

Regardless of the size of your company, having a proper inventory management system is very important for any business. It can help you keep track of all your supplies and determine the exact prices. It can also help you manage sudden changes in demand without sacrificing customer experience or product quality. This is especially important for brands looking to become a more customer-centric organization.

Balancing the risks of overstocks and shortages is an especially challenging process for companies with complex supply chains. A company's inventory is typically a current asset that it plans to sell within a year. It must be measured and counted regularly to be considered a current asset.

3. Target Specifications and Characterization:

Organizations face a lot of internal and external risks, like high competition, labor unrest, high risk and change in government laws. So, a lot of the decisions an organization makes are under conditions of risk and grave uncertainty. These risks can be reduced by predicting the demand for sales of its products and services in the future. Demand forecasting is a systematic process of anticipating the demand of a product or service offered by the organization in the future under a set of unpredictable and competitive forces. In this paper we use the XGBoost regression model to perform demand predictions. XGBoost is a machine learning algorithm which uses decision trees.

4. External Search:

The sources which i have referred to gather information regarding inventory management using Machine Learning are mentioned below:

a) [Warehouse Management & Machine Learning Use Cases](#)
b) [Machine Learning in Warehouse Management!](#)
c) [Machine learning for planning in warehouse management](#)
d) [Warehouse Management & Machine Learning and Use cases](#)
e) [Warehouse Optimization based on Machine Learning](#)

4.1 Benchmarking:

4.1.1 Inventory management using machine learning: LOWE'S

It's a home improvement retail chain with stores located all over the United States. In mid-2016, they introduced LoweBots–autonomous retail robots. Although their primary goal is to help customers locate products they need, LoweBots do more. They gather real-time data by using computer vision and machine learning algorithms to scan inventory and look for patterns in product or price discrepancies. As a result, they are extremely helpful both for customers and the company itself.
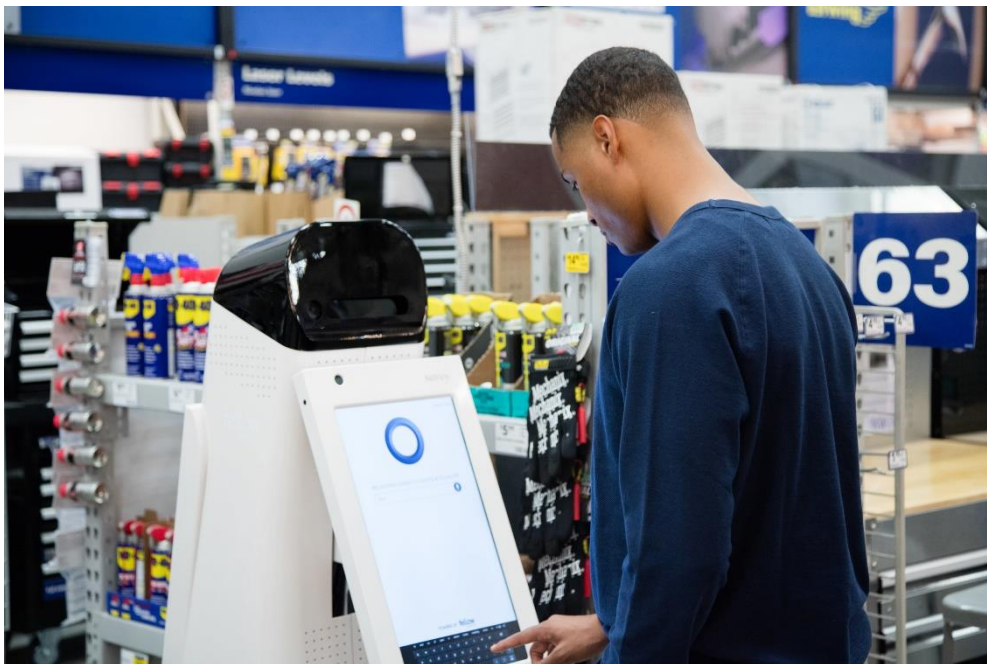
4.1.2 Inventory management using machine learning: AMAZON

This company needs no introduction, as they are a global e-commerce leader. What you may not have known, they also have their own warehouses and logistics services (Amazon Fulfilment). In 2012, Amazon bought Kiva Systems (currently known as Amazon Robotics), a robotics company, for 775 million USD. This investment was not in vain! Today they have tens of robots in their warehouses worldwide. These robots are helping the company pick and pack parcels and fill orders more quickly and efficiently.

5. Applicable Patents:

a) Inventory management system **:** This invention relates to inventory management systems and, more particularly, to methods and systems for performing an inventory management process that uses an intelligent station to track and/or inventory items that are tagged with Radio Frequency Identification (RFID) tags.

b) [Method and system for inventory management](#) : The invention pertains to computer systems and computer-implemented methods for managing inventories, such as inventories of aftermarket automotive parts. In accordance with the invention, a programmed computer generates order data (e.g., indicating whether to reorder a part) in response to reference data (sales, inventory, and/or market data) concerning vendors at the same level of a part distribution chain (i.e., at a single part distribution level). The computer can be operated by personnel of one vendor and receive reference data concerning at least one other vendor at the same distribution level, or can be a host computer which receives reference data concerning two or more vendors at the same distribution level.

6. Applicable Regulations:

a. Patents on ML algorithms developed
b. Protection/ownership regulations
c. Being responsible by design.
d. Ensuring open-source, academic and research community for an audit of Algorithms.
e. Review of existing work authority regulations
f. Government Regulations for businesses.

7. Applicable Constraints:

a. Fluctuation in demand
b. Inadequate inventory planning
c. Backlogs of orders
d. Uncertainties in logistics
e. Communication gaps within the availability chain
f. Shortages in supply

8. Concept Generation and Development:

Organizations face a lot of internal and external risks, like high competition, labour unrest, high risk and change in government laws. So, a lot of the decisions an organization makes are under conditions of risk and grave uncertainty. These risks can be reduced by predicting the demand for sales of its products and services in the future. Demand forecasting is a systematic process of anticipating the demand of a product or service offered by the organization in the future under a set of unpredictable and competitive forces. In this paper we use the XGBoost regression model to perform demand predictions. XGBoost is a machine learning algorithm which uses decision trees. In prediction problems that have the data unstructured Neural

networks outperform other prediction algorithms, but in our case the data is structured and tabulated, and decision tree algorithms are considered best for structured data. Hence, we decided to go with the XGBoost algorithm for demand forecasting.

9. Final Design:

The proposed architecture is collectively obtained from five components: Data Ingestion, Data Pre-Processing, Storage, Feature Extraction, ML model. The architecture of Inventory Management Using Machine Learning is as shown in Figure:
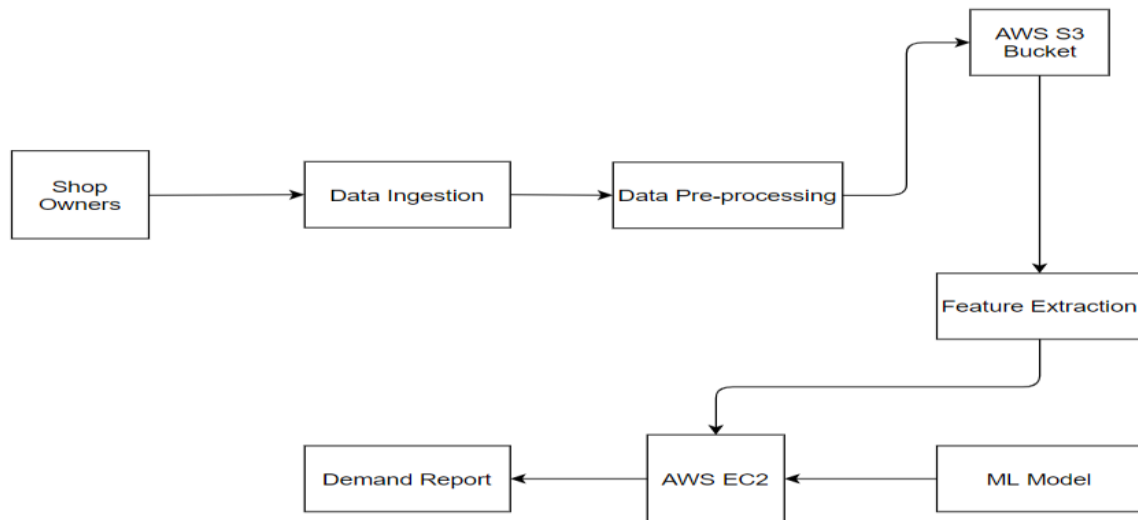
A. Data Ingestion: Initially, shop owners can login to the system and add their product details which is stored in a database. Also, the historical sales data is recorded in the database. This data, which is used to train the ML model, is ingested to the system. The training data used consists of several thousands of rows

B. Data Pre-processing: Data pre-processing is a data mining technique which is used to transform the raw data in a useful and efficient format. The data ingested is cleaned before it is used for training the model. Hence, the unnecessary fields are eliminated from the database. Pre-processing also involves the transformation of raw data into an understandable format.

The training data has weekly demands of all the products as shown in table 1. Starting from the third week till the seventh week. Hereby, the trend in weekly demands was analyzed.

C. Storage: S3 stands for Simple Storage Service. Amazon Simple Storage Service (Amazon S3) is an object storage service that offers industry-leading scalability, data availability, security, and performance. S3 enables customers of all sizes and industries to use it and protect any amount of data for various use cases, such as websites, mobile applications, backup and restore. It is designed for 99.999999999% (11 9's) of durability. The pre-processed data is stored in the S3 Bucket.

D. Feature Extraction: The data stored in S3 bucket contains several fields. With the help of proper feature extraction, the accuracy of model can be increased, hence only certain fields of the dataset were extracted for training. For example, the training data consists of product name as well as product ID. Only product ID is required to train the model. Thus, only the required features are extracted from the dataset and used to train the model.

E. ML Model: An algorithm called XGBoost is used as the machine learning model. XGBoost is an ensemble algorithm which is based on decision-trees and uses gradient boosting framework. It was evolved from basic bagging algorithm. Normally prediction problems consisting of unstructured data neural networks tend to perform poorly when compared to other algorithms or frameworks. However, when it comes to small-to-medium, structured/tabular data, decision tree-based algorithms perform well.

F. Report: The demand values for the next 2 weeks are predicted by the XGBoost model. The predicted demand values are real numbers. To get actual demand values, the values were rounded. The predicted values are output as a report to the shop owners aiding for an efficient inventory management.

10. Model Implementation:

The model utilized to perform the prediction is known as XGBoost (Extreme Gradient Boosting) regression model. XGBoost is an ensemble decision tree machine learning algorithm. When the data is small and structured, these decision tree-based algorithms outperform other algorithms. XGBoost algorithm was evolved from Bagging Algorithm.
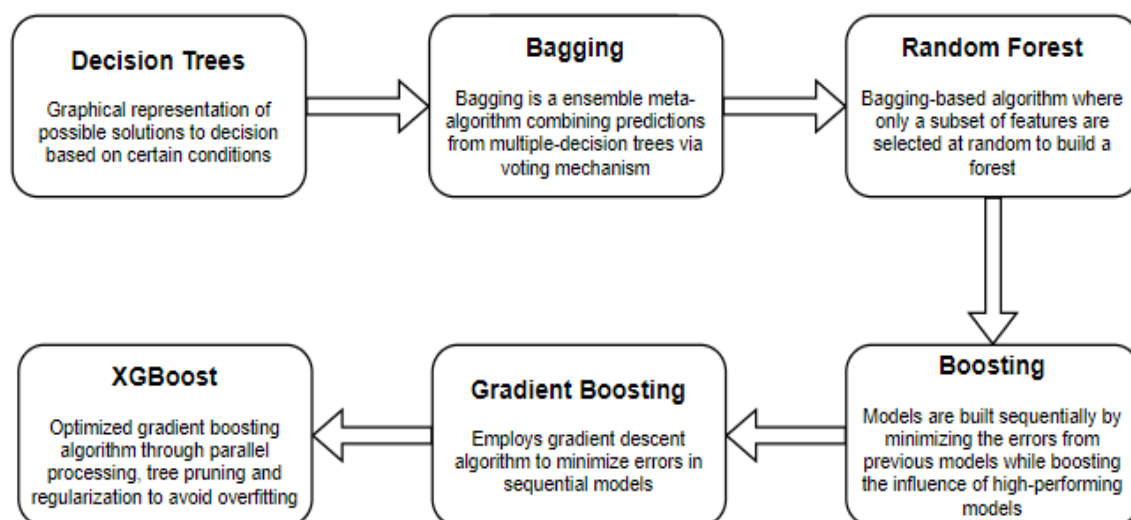
The evolution of the XGBoost can be better understood from the figure, which makes it highly suitable for implementing large amount of data.

A. XGBoost Working: The XGBoost constructs the decision trees based on the error factor obtained from the previous tree. The technique followed is like that of a normal tree boosting except the way error calculated from the loss function is different.

The XGBoost follows certain steps;

 i. Model fitting to the data,
 ii. Model fitting to the residuals,
 iii. Generating new model (where the new model is boosted version of the old),
 iv. Repeating all the steps till error is improved.

B. Training the model: After the model is implemented, training of the model is necessary to predict the demand with better accuracy. The train_test_split is a function for splitting data arrays into two subsets: for training data and for testing data. With this function, eliminates the task of splitting the dataset manually. By default, train_test_split will make random partitions for the two targets x and y. The model is trained using an approach known as early-stopping-rounds which helps to avoid overfitting. It works by halting the training when there is no increase in the performance on the test dataset up to the specified number of iterations (i.e. up to 100 in our case). It can automatically circumvent overfitting by considering the point of inflection where the performance starts to decrease on test data while for the training data goes on improving towards overfit.

11. Conclusion:

The Demand Forecasting will help Small/Medium businesses to maintain inventory and minimize manual labour. Allowing it to reduce the capital spent on maintaining inventory. In this process it aims at simultaneously improve in profitability. With the forecasting technique, the overstock and stock-out of items are reduced as the stocks are ordered based on the Demand. In the future, the accuracy of the model can be improved by incorporating categorical embeddings in neural networks as it is still a budding topic in the field of neural networks and requires more research.