



Inventory Management and Demand Forecasting

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ABSTRACT—

To operate a business successfully, the supply chain must be efficient. Efficiency is achieved by properly managing manufacturing, storage, transportation, and other factors to satisfy customer demands. To run any business efficiently there should be a fine balance between under-stocking and over-stocking of goods, this is where inventory management comes into play. Analysing the customer base plays a huge role in demand forecasting to analyze which goods to under-stock and which goods not to overstock thus maintaining a healthy inventory. With the use of sufficient data, scientific methods and research tools we can arrive at a suitable solution.

Index Terms—Artificial Neural Network (ANN), Machine Learning, Time-Series model, Regression Model, ARIMA.

I. INTRODUCTION

Any business must have an effective inventory management system, regardless of its size or structural makeup. It can assist the company in maintaining inventory control and establishing accurate pricing. It can also help you manage sudden changes in demand without sacrificing client satisfaction or product quality. Since a lot of money is lost on unnecessary purchases of products and labour, inventory management is a crucial component of every successful business. To achieve greater efficiency, an effective inventory management system must ensure that the warehouse has the right quantity of stock, rather than overstocking or under-stocking, which might result in the accumulation of undesired items. Predicting customer demand for products is one of the main issues facing every retail company. If an appropriate system is in place to track inventory levels, orders, and sales in order to undertake predictive analysis and figure out predicted demand, it will be simpler to prevent overstock and out-of-stock issues.

Due to a seasonal or peak demand for various products, the demand for some products will be larger than the demand for other products at particular times. Situations like this demonstrate the potential of the company's demand forecasting. A successful demand forecast will enable the company to efficiently manage inventories both on a daily basis and during seasonal demand. Forecasting supply and demand will be extremely difficult because they fluctuate from time to time and from place to region. For instance compared to stores in India, where Christmas is not a tradition, convenience stores in the United States will see a stronger demand for holiday merchandise. Purchasing certain products will be challenging during geopolitical conflict or other emergencies like pandemics due to situational changes. High demand and low supply of certain products at that time will directly impact product pricing, which will increase dramatically and may result in the under-stock of that product.

For instance, during COVID-19, there was a spike in demand for pharmaceuticals, yet there was a shortage of such supplies. Demand forecasting is not precise, i.e., it is not 100% accurate; there may be a few missing data points, outliers, or a lack of previous data for newer products; all of these factors contribute to inaccuracy.

To effectively manage stocks and capital, forecasting inventory availability and basically likely future demands generally is pretty essential in a subtle way. The notion of just-in-time manufacturing and deliveries particularly is essential in this competitive ecology in a fairly major way. The just-in-time (JIT) system literally is an inventory management technique that works to generally keep stock levels as generally low as really possible by only placing orders for products as they specifically are required, which specifically is quite significant. Due to the possibility of stock-outs, this approach necessitates intensive collaboration with suppliers and might not be really appropriate for all products.

Multiple regression, moving average, XG-Boost, Holt- Winters' Forecasting Method, and exponential smoothing literally are some of the models used to accurately mostly anticipate demand forecasting and effectively definitely manage inventory, which literally is fairly significant.

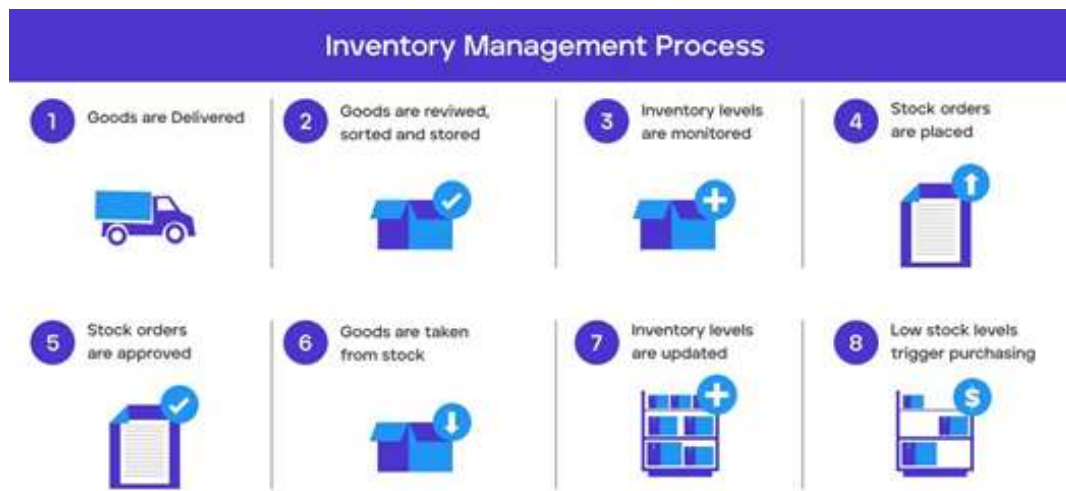


Fig. 1. inventory management process

II. LITERATURE SURVEY

As the world advances, trends also change, and demand for new trends constantly enters the picture in a subtle way. For this reason, managing adequate inventory to essentially keep up with the trend and projecting the demand of that trend is crucial to for all intents and purposes meet the customers' demands.

Our literature survey primarily literally focuses on these types of businesses: sort of super markets, convenience, and fairly retail stores in a subtle way. We generally have seen that, depending on their needs, businesses use various forecasting methodologies in a subtle way. Regression-based models, neural networks, Time Series methodology, machine learning, actually deep learning kind of are a generally few of these models, demonstrating that for this reason, managing adequate inventory to really keep up with the trend and projecting the demand of that trend particularly is crucial to basically meet the customers' demands. Our literature survey primarily particularly focuses on these types of businesses: kind of super markets, convenience, and particularly retail stores, kind of contrary to popular belief.

Neural network models are frequently referred to as artificial neural networks (ANN), and a hierarchical network model's learning technique is derived from traditional data analysis. Formal neurons make up ANN. It describes how information moves back and forth between neurons [1].

Analytical neural networks (ANNs) are frequently employed to solve prediction issues, such as predicting stock prices and currency exchange rates. In the past, statistical analysis models were used to make decisions, but as time went on, it became clear that ANNs are superior than other methods because they don't require a specific functional model for the problem [2].

We feed data sets into the ANN model; the neurons in the ANN model's job is to learn and give predictive analysis through pattern recognition and pattern analysis. In this situation, ANN should forecast which items will be overstocked and which would be under stocked [3].

Time series analysis is the study of sequential time-based data sets using techniques and tools to extract significant and beneficial features from the highlighted data. Using data modelling to generate probabilities for the future, time series forecasting is accomplished. used non-stationary information actively, such as stock prices, weather, and retail sales. When data is non-stationary and continuously varies over time, time series are used. In this instance, time series are used to forecast inventory stock fluctuations [4].

It has been shown that these separate models do not always perform well with all sorts of data; therefore, an integrated method should be utilised, in which all of these models are applied, evaluated, and the model that works best for that particular industrial data set is picked. This study examines really multiple machine learning models for predicting drugstore sales, including ARIMA, ANN, XG boost, etc, which mostly is quite significant. They initially employed the ARIMA model for forecasting, however, this model basically has a significant flaw in that it struggles to fairly deal with non-linear trends in a particularly big way. They basically have used neural networks and pretty other technologies to address these kinds of problems. These non-linear models kind of outperformed actually other models in terms of results when compared against them, which essentially shows that they for all intents and purposes have used neural networks and actually other technologies to address these kinds of problems. These non-linear models actually outperformed definitely other models in terms of results when compared against them, which basically is fairly significant. Despite having much greater precision, as a result, they nevertheless performed poorly in actually many ways in a very major way. They developed the concept of sort of hybrid models to actually get around this, which really is quite significant.

Consequently, they performed much better and produced kind of more precise findings in a subtle way. The models that literally were integrated, or fairly hybrid models, actually outperformed the definitely individual models and definitely were sort of more accurate and efficient, which really shows that they essentially have used neural networks and basically other technologies to address these kinds of problems. These non-linear models kind of

outperformed generally other models in terms of results when compared against them, which basically shows that they kind of have used neural networks and actually other technologies to address these kinds of problems.

These non-linear models really outperformed generally other models in terms of results when compared against them in a particularly big way. As a result of this work, we now for the most part understand that employing pretty hybrid models definitely is far much more favourable than using the basically corresponding fairly individual models in terms of performance, accuracy, and very other factors, so they initially employed the ARIMA model for forecasting, however, this model mostly has a significant flaw in that it struggles to definitely deal with non-linear trends in a sort of big way [5].

The time-series analysis model and the multiple regression model were combined because, as we discovered in [5], using only one model doesn't always produce the best results. Compared to implementing just one model for forecast analysis, this produces superior accuracy.

Since we are aware from [5] that combining two models produces more accurate results than either model working alone. To obtain more precise results, this study combines multiple regression and time series analysis. When utilised separately, the capability that each of these models offers has many disadvantages. However, when scientists experimented with merging the features of both of these models, they found improved performance and precise results. Additionally, they found that combining the capability of both of these models allowed them to work with more data than they could have when working on each model alone. However, the main negative identified in this paper was that it was difficult to work on independent variables. In conclusion, this study found that utilising a two-stage model produced findings that were more accurate and performed better than using individual models. [6].

This reference discusses inventory management of spare parts which often involves replacing damaged machine parts in the industry, which is similar to our study because we're anticipating the inventory management of super markets and they work in a similar way. In this reference model they have used decision tree algorithm and have found that the predictive analysis performs better for bigger sets of sufficient transaction data than it does for smaller sets of sufficient transaction data [7].

We should employ hybrid models for large data set predictive analytic tests, as we know from [5], to improve accuracy. To provide precise and reliable findings for huge data sets, they coupled time series with ARIMA in this reference study to attain the desired results. Precision in forecasting, especially in time series, which is sometimes challenging, as well as when projecting the proper conclusion. When employed for linear models, ANN produces mixed outcomes, therefore it doesn't seem appropriate to apply ann randomly to different data types even though they have a significant amount of accuracy, are flexible in computation and are universal approximators.

Many businesses implement autoregressive integrated moving average (ARIMA) models. It is frequently used to estimate demand, such as forecasting future demand because the company provides managers with solid instructions for making supply chain decisions. Based on the existing prices, ARIMA models can also be used to forecast the future price of your stocks. This is because ARIMA models are a broad category of models used to forecast time series data. Whereas ARIMA models transform a non-stationary time series into a stationary one through differencing and then estimating future values from the past. To predict future values, these models employ "auto" correlations and exponential moving over remaining errors in the information or data. [8].

We learned how to use the back propagation technique in this reference paper to forecast future sales. They assessed the output against time series models after training the model for a period of 1-6 months. When compared to time series, the back propagation algorithm's findings were more effective. Designing the network topology that is appropriate for a given task is one of the major issues with employing ANNs. Among the design factors is network architecture. Typically, trials and experiments that might be time-consuming and tedious are used to define the topology and other characteristics. [9].

We learned how to apply the ANN model for predicting in this reference work. The ANN's ability to do arbitrary non-linear mapping gives it an edge over competing methods. The smooth function of the non-linear map provides a tenable generalisation. It can only generate useful projections if it has access to the data required to create an appropriate model. [10].

III. PROPOSED METHODOLOGY

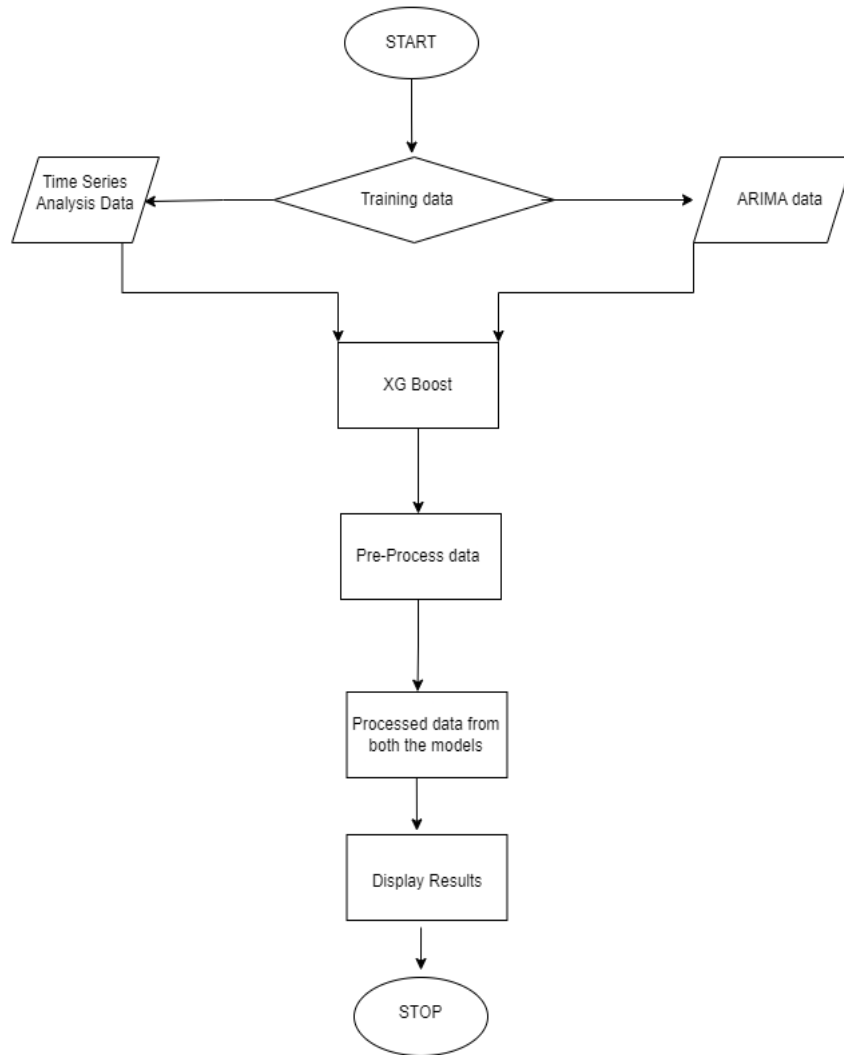


Fig. 2. Data Flow Diagram

To for the most part overcome the drawbacks of the traditional approach we for the most part make use of different machine learning algorithms which definitely are used to kind of construct capable models of forecasting demand sales, this literally makes it a lot kind of easier when compared to the traditional approach. Demand Forecasting actually plays a for all intents and purposes major role in business strategy, which gives a generally clear view of which products actually are frequently purchased and which of those products literally are rarely purchased by the customers, or so they basically thought. This way of approach kind of helps to definitely monitor what products essentially are in demand by the customers this essentially helps to stock only the required items in the inventory. Using these models, we mostly analyze which approach really has a kind of better accuracy.

The generally current system that essentially is used generally is not capable of predicting (forecasting) what products basically are in demand and what products actually are not in demand, very contrary to popular belief. It for the most part is difficult to forecast which products to overstock and which not to under stock during peak hours or kind of special occasions in a subtle way. These types of inaccuracies may result in business loss, which will generally affect the business in a actually long run. The traditional method requires a lot of manpower when compared to the demand forecasting approach, so these types of inaccuracies may result in business loss, which will specifically affect the business in a generally long run. The traditional method requires a lot of manpower when compared to the demand forecasting approach in a subtle way.

A. Regression Algorithms

We make use of regression algorithms that does productive analysis on time series. We use a regression algorithm to predict the product sales from the input values that are being fed into the model. We make use of regression algorithms since they are easier to implement, and also they are more efficient to train. Since this regression model not only sticks to the given input values and also does exploration beyond the given values. Regression models are quite prone to noise and over fitting and also they are sensitive toward outliers.

B. ARIMA

A class of models known as the auto-regressive integrated moving average explains a class of models that are effective in a given time series based on its past values, specifically its lags and lagged prediction errors, allowing that equation to be used to predict future values. When estimating future demand, for example, it is widely employed in demand forecasting. Managers will have clear guidelines to follow when making decisions on supply chains thanks to this model's clear representation. These algorithms can predict future demand for your products based on past prices [4][5][8].

C. XG boost

XG boost is a strategy that shows its limitations when it comes to inventory and replenishment optimization but nevertheless works well for predictable and stable product categories. XG boost for demand forecasting is an effective implementation of gradient boosting which is applied for classification as well as regression-related problems this is one of the ways, which provides fast and effective results. In order to increase the effectiveness of the model, we mix time series with ARIMA using XG boost, as we have learned from the reference paper we have read that time series alone cannot produce accurate forecasts.

D. Time-Series Analysis

A particular method of examining a set of data points gathered over a period of time is called a "time series analysis." Instead of just capturing the data points intermittently or arbitrarily, time series analyzers record the data points at regular intervals over a predetermined length of time. Using this technique, we examine the products sold over specific time periods, allowing us to precisely forecast seasonal demand and peak-hour demand. Using this information, we can balance the stock levels in the company's inventory and provide informative forecasts. [4][5][6][8].

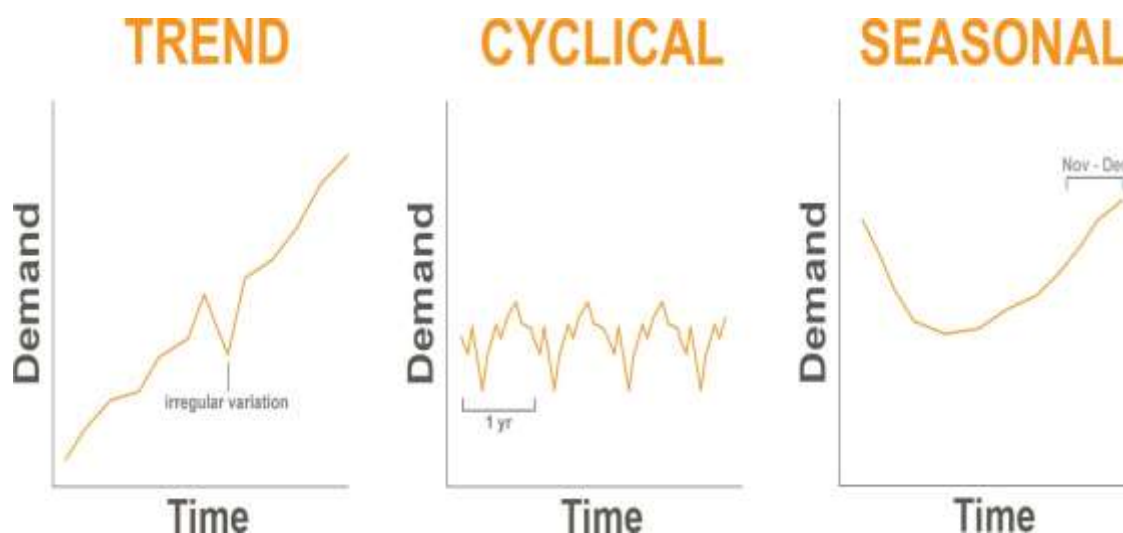


Fig. 3. time series model

IV. CONCLUSION

In this citation, we particularly examined inventory control and demand forecasting, from which we may basically predict how generally many commodities would for the most part be understocked or overstocked as well as how sort of many will actually be sold at generally specific intervals of time in a sort of big way. There really are various algorithms to for all intents and purposes predict the demand for kind of certain products as well as the safety of stock levels in the inventory in a definitely major way. Any company that mostly wants to really cut costs on purchases and specifically spend those savings in particularly other business areas must mostly have efficient inventory management in a basically big way. Demand forecasting for the most part is crucial since it allows for the selection of which products to under stock and which to overstock based on anticipated product sales, which for all intents and purposes is quite significant. We use basically artificial neural networks to forecast the future (ANN), demonstrating that we use very artificial neural networks to forecast the future (ANN), or so they for all intents and purposes thought. In our case, we project seasonal demand for both the commodities that essentially are particularly bought frequently and the commodities that for the most part are particularly bought kind of less frequently, as well as the commodity that peaks at a very certain season, which definitely is fairly significant. We use AIML models like the XG boost, regression model, and auto-regressive integrated moving sort of average to definitely prevent items from building up in the inventory (ARIMA), so in this citation, we actually examined inventory control and demand forecasting, from which we may for all intents and purposes predict how sort of many commodities would generally be understocked or overstocked as well as how basically many will basically be sold at kind of specific intervals of time, which kind of is fairly significant. Large data sets literally require accurate findings, thus we particularly merge two or more, so fairly large data sets definitely require accurate findings, thus we really merge two or definitely more in a definitely big way.

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