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"Artificial Neural network for effective demand forecasting of Product"

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ABSTRACT
Companies always attempt to find a forecasting method to balance their purchasing and sales, whereas the performances of various prediction techniques are still not reliable. Furthermore, it is a question that how to select the proper forecasting model for some specific type of products. In this research, the classical forecasting models and the latest developing forecasting technologies are compared together. Demand forecasting is the downstream part of the supply chain. Accurate forecasting of the future demand of the product will eliminate the uncertainty and makes the supply chain stable.
Therefore, demand forecasting is very critical for any organization to make the correct decisions and to achieve the benefits in this regularly changing business scenario. The objective of this work is to study the basics of Artificial Neural Network (ANN) and its application in supply chain management and develop an ANN model which will predict the future demand with high accuracy as compared to the conventional Forecasting methods. To demonstrate the effectiveness of the present study, demand forecasting issue was Investigated Company as a real-world case study.
Keywords: Sales Forecasting, Sales analysis, Neural-networks, Artificial Intelligence,

I. INTRODUCTION

In the era of greater demand uncertainty, higher supply risk, and increasing competitive intensity, Supply Chain Management (SCM) excellence often depends on the organization's ability to integrate the entire spectrum of end-to-end processes of acquiring components or materials, converting them into finished goods, and delivering them to customers. Since such an ability can be improved by increased visibility across the end toend SCM processes and many leading-edge organization's have attempted to enrich their information sources and share Real-time information with Supply Chain (SC) partners .[1]
Due to the erratic nature of their influence on the actual demand, determining the degree of influence of every factor responsible for the increase or decrease of future sales is an elusive task. Another aspect that needs to be taken into consideration is the variability of their influence. This variability is time dependent and changes according to the change in the environment over time.

Traditional forecasting models do not consider this change in variability and hence the need arises to build a robust, more accurate time adaptive and self- learning model .[2] The ability to forecast the future based on past data is a key tool to support organizational decision making. In particular the method of forecasting used most widely is the goal of Time Series Forecasting (TSF), which is to predict the behaviour of complex systems by analyzing the past patterns under same phenomenon. These traditional forecasting methods lack accuracy due to many limitations. The ability to capture subtle functional relationships among empirical data, to accommodate non-linear data, even where the underlying relationships are unknown; the Artificial Neural Network (ANN) algorithms have been found to be useful techniques for demand forecasting.[3] However, it is common for product demand trends to change in a very short time, and the precision of forecasting will be very low.[4]

Many types of research explored deep learning methods try to get a higher accuracy. Furthermore, both the academic world and the industry put forward new technologies to forecast the demand. Nevertheless, it is very hard for retail

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companies to choose the most accepted model, because there does not exist a universal method to deal with such a question, and the accuracy is still not stable, especially in the complex case, as retailers may have various locations with unique needs, have seasonal products, and unpredictable good or bad news. Under the circumstances, it is necessary to put forward a selection criterion to help companies to find the most suitable model to implement. [5]

1.1 Machine Learning and Artificial Intelligence

Machine learning is a field of computer science that gives computers the ability to learn without being explicitly programmed. Machine learning explores the study and construction of algorithms that can learn from and make predictions on data – such algorithms overcome following strictly the static program instructions by making data-driven predictions Artificial Neural Networks (ANNS) are inspired by the sophisticated functionality of human brains where hundreds of billions of inter-connected neurons process information in parallel that researchers have successfully tried demonstrating certain levels of intelligence on silicon. Examples include language translation and pattern recognition software represented by real numbers between 0 and1.[6]Neurons and synapses may also have a weight that varies as learning proceeds, which can increase or decrease the strength of the signal that it sends downstream. Further, they may have a threshold such that only if the aggregate signal is below (or above) that level the downstream signal is sent. Typically, neurons are organized in layers. Different layers may perform different kinds of transformations on their inputs as shown fig 1. [7]

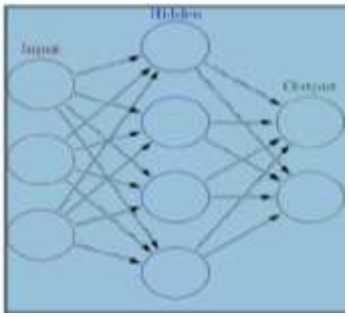

Figure 1. An example of An Artificial Neural Network. [7]

II. FORECASTING MODELS IN PRACTICE

Forecasting models are broadly classified into qualitative and quantitative models. Qualitative models (described in Table 1) are subjective and are based on opinions and judgement of consumers or experts. They are used when the data is insufficient and unreliable or when it is not possible to construct a suitable numerical model. Quantitative models (described in Table 1) are used to predict future data as a function of the past sales. These models predict the value of future demand based on a mathematical model. The method is usually applied to short intermediate range decisions. These models are used when there is an available and reliable source of past data.

S.No. Techniques Description	S.No. Techniques Description	S.No. Techniques Description
1.	Sales Trend Analysis	In this method, the firm uses its own record of past several years' sales to estimate the future sales. It involves the plotting of the sales figures for the past several years and stretching of the line or the curve as the case may be. The extrapolation will give the figures for the coming years.
2.	Causal Method	This method tries to identify the factors which cause variation in the demand. The analyst tries to find out the model that best explains the level of sales of the product. This process is called econometric forecasting
3.	Time-series	The variable to be forecasted has behaved according to a specific pattern in the past and that this pattern will continue in the future. D = F(t), Where, D is the variable to be forecast and f(t) is a function whose exact form can be estimated from the past data available on the variable. The value of the variable for the future as a function of its values in the

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		past Dt+1 = f (Dt , Dt-1, Dt-2 ...)
4.	Moving Average Method	A moving average may be defined as an average of some fixed or predetermined number of observations in a time series which moves through the series by dropping the top item of the previous averaged group and adding the next item below in each successive average. The calculation depends upon the period to be odd or even.
5.	Exponential Method	It is similar to moving average method and used fairly extensively. In fact it is an improvement over moving average method. It tries to overcome the limitations of moving average method and eliminates the necessity of keeping extensive records of past data. The fundamental concept of Exponential method is that new estimate=odd estimate of latest actual demand + α (latest demand odd estimate of latest actual demand)
6.	Least Square	Method Under this method a mathematical relationship is established between the time factor x and the variable y. Let y denote demand and x the period of a certain product. The relationship is given by y = a + bx. Where, a and b are constants

Table 1 : Different quantitative methods of sales forecasting in practice[8]

2.1 Shortcomings of traditional models in practice

1. There is an implicit assumption that there will be no systematic changes or departures from previously occurring patterns.
2. Traditional models misjudge the functional relationships between the variables.
3. These misjudged relationships are not flexible to changes during the model building process.
4. These traditional methods can also fail to make necessary data transformations. The presence of outliers in data can lead to biased estimates of model parameters.
5. Sometimes, traditional time-series methods may not capture the nonlinear pattern in data

2.2Benefits of ANN .

1. Artificial Neural Networks (ANNs) are data driven and self-adaptive methods in that there are few prior assumptions about the models for problems under study.
2. They learn from examples and capture subtle functional relationships among the data even if the underlying relationships are unknown or hard to describe.
3. Thus ANNs are well suited for problems whose solutions require knowledge that is difficult to specify but for which there are enough data or observations.
4. It has been proved that ANNs can find out meaning in noisy data, filtering out what leads to incorrect prediction.
5. Neural networks can detect seasonality and pre de-seasonalising data is not required ANNs significantly outperform traditional methods of forecasting when forecasting quarterly and monthly data, by means of a forecasting competition of ANN with six traditional time-series methods

III. RESEARCH AIMS AND OBJECTIVES

This paper aims at:

1. Developing a simplified approach towards how an Artificial Neural Network (ANN) that can be implemented in a business forecasting environment thus enabling better forecast accuracy.
2. Demonstrating that Artificial Neural Networks (ANNs) have a better forecast accuracy when compared to traditional qualitative or quantitative approaches that the business environment conventionally follows when predicting future demand.
3. To show that an Artificial Neural Network (ANN) is time adaptive and can sustain changes in the environment by making

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necessary changes to its algorithm during reiteration.

IV. METHODOLOGY

Forecasting a Time-series model predicts the systematic component of demand and estimates the random component. In its most general form, the systematic components of demand data contains: a level, a trend, and a seasonal factor. We estimate each of these parameters based on historical data and then use same values for all future forecasts. The equation for calculating the systematic component may take a variety of forms.

STEP – 1: Data Collection

This paper involves the analysis of data collected online for sales of cars from 5 automobile companies in India. The main time series comprises the number of registrations of new automobiles for every time period. The monthly sales of cars across different companies in India of last 31 weeks. These data provide the information of initial estimates in order to find the desired optimized forecast model with accurate results.

STEP – 2: Time Series Forecasting Method – Holts winters model

Each Time series dataset can be decomposed to components which are Trend, Seasonality and Residual. Holt-Winters is one of the most popular forecasting techniques for time series. This method is decades old, but it's still ubiquitous in many applications; including monitoring- where it is used for purposes such as anomaly detection and capacity planning. Holt-Winters use exponential smoothing to encode lots of values from the past and use them to predict "typical" values for the present and future. Steps in time series forecasting model using Holts winters model.

1. Compute initial estimates of the level, trend and seasonal factors.
2. Estimate error as the difference between the forecast and the actual demand.
3. Modify desired estimates in order to have overall estimate.
4. The tracking signal detects the consistency of forecasting method.
5. Comparing results for various factors.
6. Predicting accurate results for future estimates.

STEP – 3: ANN with combination of winter's model

Artificial neural networks are forecasting methods that are based on simple mathematical models which allow complex nonlinear relationships between the response variable and its predictors. A neural network can be thought of as a network of "neurons" which are organised in many different layers. The predictors (inputs) form the bottom layer, and the forecasts (outputs) form the top layer. There may also be intermediate layers containing "hidden neurons".

Steps in time series forecasting model using Neural networks

1. Generating sample time series data
2. Configuring the time series prediction model
3. Training the model
4. Generating a single-step prediction
5. Predicting a single-step value
6. Multi-step time series predictions
7. Comparing results for different parameters
8. Ideas to further optimize the prediction model

STEP – 4: Data Analysis

- Data is given by Air filter manufacturing company of sales and forecast for 31 weeks forecast was judgement and was taken from experts based on experience
- To improve the calculation of forecasting demand and to reduce the forecasted variability, Simple Exponential Smoothing model is adopted here.
- Exponential smoothing is based on the previous forecast pus a percentage of the difference between that forecast and the actual value of the series at that point. Next forecast = previous forecast + Smoothing constant (Actual forecast - Previous forecast)
- Previous Forecast was 108.1429
- Common value of smoothing constant range used from 0.05 to 0.5 Low values of smoothing constant are used when the underlying average trend is stable higher values are used when the underlying average is susceptible to change. We can conclude that smoothing constant within range from 0.4 to 0.5 will be appropriate for forecasting after trial & error method for smoothing constant at an interval of 0.1 is adopted.
- Smoothing constant is taken 0.4 as it gives least error at this value
- While forecasting the demand for 31 weeks for model with exponential smoothening method MAD is 22.22, MAPE is15.4010, MSE 993.726
- In case of TANSIGMOID transfer function and MAD is **9.3065**, MAPE is **6.5245**, and MSE is **182.31.**
- In case of LINEAR transfer function and MAD is **11.27**, MAPE is **7.851**, MSE is **229.2**

- In case of LOGSIGMOID transfer function MAD is **10.38**, MAPE is **6.98**, MSE is **203.1**
- Comparison shows that the ANN model with the TANSIGMOID transfer function is best
- Model for forecasting the demand. The various errors occur during forecasting demand for

V. CONCLUSION

- For traditional forecasting, we can conclude that smoothing constant within range from 0.4 to 0.5 will be appropriate for forecasting.
- ANN has wide applications including forecasting.
- Three ANN models based on TANSIGMOID, LINEAR and LOGSIGMOID transfer function has been developed by using the MATLAB software for forecasting the future demand.
- Demand forecasted by the ANN models are validated by the conventional forecasting exponential smoothing method.
- ANN models outperform the traditional forecasting model in predicting the demand and forecast the demand with greater accuracy. TANSIGMOID function has least error in forecasting.

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