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Oral-Care Goods Sales Forecasting Using Artificial Neural Network Model

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Abstract

Supply Chain consists of various components like supplier, manufacturer, factories, warehouses, distribution agents, customers, etc. Supply Chain Management encompasses all the activities from moving goods from sourcing to consumption. Sales forecasting is a part of downstream activity of supply chain and is the process of predicting future sales of the product. It helps in making informed business decisions. In this paper a study of various sales forecasting algorithms is done and results of sales of oral-care products are calculated using Back-Propagation Neural Network Model. The error rate for different products is also calculated.

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Keywords: Sales forecasting ; ARIMA; Neural Network; Supply Chain; FMCG.

1. Introduction

The supply chain comprises of all the activities associated with moving goods from the raw-materials stage to the end user [1]. A typical supply chain may involve following stages: Customers, Retailers, Wholesalers, Distributors, Manufacturers, and Suppliers. The downstream stage in the supply chain involves processing the materials collected during the upstream stage into a finished product. It also includes the actual sale of that product to other businesses, governments or private individuals [2]. Having accurate demand details and previous sales record, one can easily forecast sales using different forecasting techniques like ARIMA, SVM, ANN, Genetic algorithm,etc.

ARIMA stands for Autoregressive Integrated Moving Average model. These models are fitted to time series data to forecast the future points of data. The model is generally referred to as an ARIMA(p, d, q) model

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where parameters p, d, and q are non-negative integers that indicate the order of the autoregressive, integrated, and moving average parts of the model respectively. ARIMA models form an important part of the Box-Jenkins approach to time-series modelling. When one of the three terms is zero, it is better to drop "AR", "I" or "MA". For example, ARIMA (0, 1, 0) is I (1), and ARIMA (0, 0, 1) is MA (1) [3].

Support Vector Machine (SVM) is a machine learning technique which comes under classification method that is based on the construction of hyper planes in a multidimensional space**.** Support vector machine (SVM) is a useful technique for pattern recognition, object classification, regression analysis and time series prediction [4]. For a given set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that predicts whether a new example falls into one category or the other. SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on. A linear support vector machine is composed of a set of given support vectors z and a set of weights w. The computation for the output of a given SVM with N support vectors z1, z2, … , zN and weights w1, w2, … , wN is then given by, [5]

$$F(x) = \sum_{i=1}^{n} w_i < z_i, x_i > + b \quad (1)$$

Artificial Neural Networks are models inspired by biological neural networks and are used to estimate or approximate functions that can depend on large number of inputs and are generally unknown. They consist of input layer of nodes, one or more hidden layers and an output layer of nodes. There are different types of neural networks like Feed-forward networks, Feed-backward networks, Radial Basis Functions, Kohonen Self organizing networks, etc. The function of neural network is described as follows:

$$Y_j = f(\sum_i w_{ij} X_{ij}) \quad (2)$$

Where Y_j is the output of node j, f (.) is the transfer function, w_{ij} is the connection weight between the node j and node i in the lower layer and X_{ij} is the input signal from node i in the lower layer to node j [5]. In ANN modelling, the historical data from the given time series would serve as the input data and the output would be the forecasted data [6].

1.1. Back Propagation Neural Network Model

Back Propagation learning algorithms were proposed by Rumelhart et al.[7]. They are common and popular methods of training neural networks. In the learning process, BPLAs use gradient descent method to optimize the whole learning process. The structure of a back-propagation ANN is shown in figure 1.

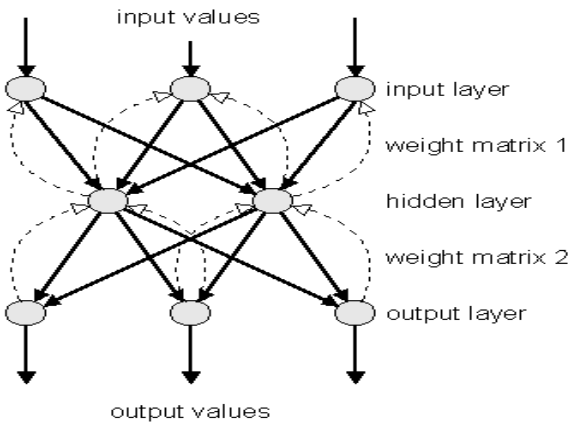

Fig. 1 Back-propagation neural network model [8]

1.2. Fast Moving Consumer Goods (FMCG)

Fast Moving Consumer Goods (FMCG) or Consumer Packed Goods (CPG) are products that are sold quickly and at relatively low cost. Examples include soft-drinks, personal care products, etc. FMCG products have shorter shelf life, either because of high consumer demand or the product deteriorates rapidly. Though the total profit margin on FMCG goods is low, but due to sales of large quantities of goods the cumulative profits are substantial [9][10].

This paper simulates the forecast of various oral care products using neural network technologies and the error rate is calculated using different accuracy measures. The rest of the paper is organized as follows: Section 2 explains the Methodology of Forecasting. Finally Section 3 shows the simulation of forecasted results using Neural Network Model and Section 4 concludes the proposed work and offers future directions.

2. Methodology for Forecasting

Sales forecasting methodology follows the following steps:

- Data gathering and processing
- Choosing the model for forecasting
- Forecasting the results
- Evaluating the results

2.1. Data gathering and Processing Phase

The procedure for data gathering and processing phase is as follows

- Decide the type of product and their respective target audience.
- Gather data of the past sales of the product.
- Check out the latest trends in the market related to the product.
- Also check for seasonality variations.
- Detect the outliers and missing data.

2.2. Choosing the model for forecasting

Based on the seasonality and trends, choose the appropriate model for forecasting.

2.3. Forecasting Results

Once the models are chosen, forecast the sales of the product using the chosen model.

2.4. *Evaluating the Results* [11]

Calculate the error rate using various measures to calculate the error rate. The different measures for calculating error are as follows:

a) Error (e_i) = Actual value – Forecast Value

b) Mean Absolute Deviation(MAD):

$$MAD = \frac{\sum_{i=1}^{n} |e_i|}{n} \quad (3)$$

c) Mean Squared Error (MSE)[12]:

$$MSE = \sum_{i=1}^{n} e_i^2 \quad (4)$$

d) Root Mean Squared Error (RMSE)[12] :

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} e_i^2}{n}} \quad (5)$$

3. Simulation of Sales Forecasting using Neural Network Model

In this section, forecast and prediction error for different oral care products is calculated using Back Propagation Neural Network Model.

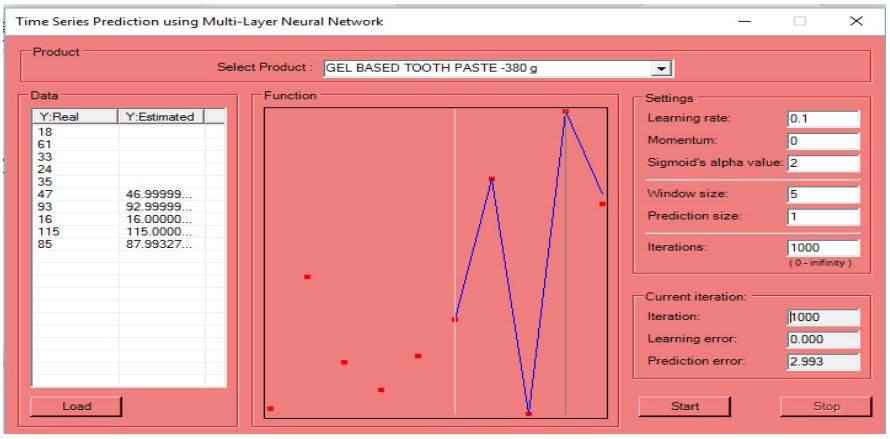

Fig. 2.Forecast result for Gel Based Toothpaste (380gm)

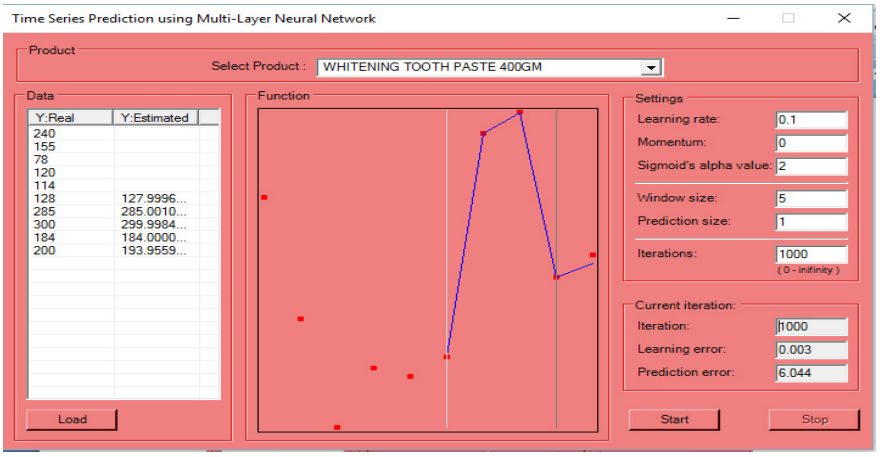

Fig. 3. Forecast Result for Whitening Toothpaste (400gm)

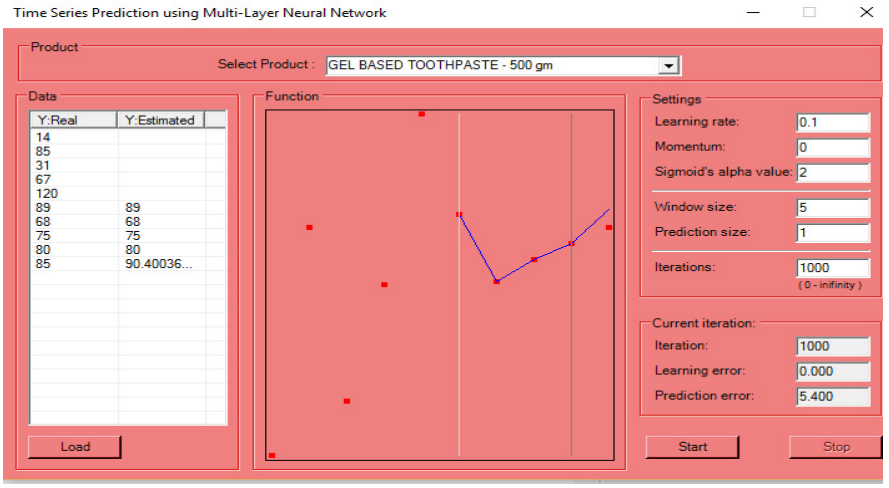

Fig. 4. Forecast Result for Gel Based Toothpaste (500gm)

Figure 2, Figure 3 and Figure 4 shows the result of simulation for different types of oral care products. The learning rate, momentum and Sigmoid's alpha value are kept constant for three products and the learning error and prediction error is being calculated.

3.1. Observations

Table 1: Error Calculation

Error Rate	Gel Based-380gm	Whitening toothpaste	Gel Based-500gm
MAD	0.5986	1.208	1.1
MSE	1.716	7.2	5.8
RMSE	0.34	1.44	1.16

Table 1 shows the error rate calculated for the 3 products using Mean Absolute Deviation, Mean Squared Error and Root Mean Square error. The accuracy of the neural network model is validated from the table 1and it can be concluded that the proposed model can be used for forecasting of fast moving consumer goods.

4. Conclusion and Future work.

This paper describes the methodology of Forecasting in detail. Oral Care Products sale is forecasted with the help of Back Propagation Learning Algorithm and the accuracy of forecast is validated. Thus it is concluded that neural network gives accurate results of forecasts and can be used for predicting the sales of FMCG products; although choosing of the model for forecasting will totally depend on the type of dataset.

Future Research may try to study the use of different forecasting algorithm on the same dataset and compare the results of the two models.

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