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SALES FORECAST IN INDUSTRIES USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Artificial Neural Network (ANN) is a computational tool inspired by the current understanding of the human brain. ANNs have been investigated by many researchers for the sales forecast of various kinds of commodities taking into account various market conditions. This paper is intended to give an exposure to the applications of artificial neural networks (ANNs) for the sales forecast. The ANN theory is discussed with special reference to multi-layer feed-forward network together with error back-propagation learning algorithm. The specific features of the ANN, making it a potential candidate for sales forecast is presented. Finally, publications in the development of ANN applications for the sales forecast in typical industrial setups, such as retail shops, supermarkets, textile industry, food industry, apparel industry fashion industry, and automobile industry are reviewed to bring out the current status and scope for further research.

KEYWORDS: *Apparel Industry, Artificial Neural Networks, Fashion Industry, Food Industry, Retail Shops, Sales Forecast, Supermarkets, Textile Industry*

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INTRODUCTION

In the present globalized market, sales forecasts are becoming more and more important for various industries to make their business plans more accurate and thus more competitive. Enhancing sales and operations planning through forecast analysis and business intelligence is demanded in any industry and business. Accurate sales forecast can reduce inventory costs and shortages. It would increase profits for the business by reducing wasted resources and allow planning for appropriate future production. A sales forecast involves the estimation of sales volume that a company can expect to attain within the plan period. An accurate sales forecast necessitates a careful and appropriate consideration of (i) general economic condition of the firm and also the consumers (ii) Consumer composition by age, sex, type, and economic condition, and their behavioral trend in fashions, religious habits and social group influences.(iii) Industrial Behaviors such as the pricing policy, design, advanced technological improvements and promotional activities of similar industries (iv) Changes within Firms such as the changes in pricing, advertising policy and quality of products. The sales forecasts are broadly categorized as

(i) Short-run forecasts, covering a maximum of one year or it may be half-yearly, quarterly, monthly and even weekly. These are useful for the estimation of stock requirements, providing working capital and establishing sales quotas. It facilitates the management to improve and coordinate the policies and practice of Marketing-production, inventory, purchasing, financing etc. A short-run forecast is preferred to all types and brings more benefits than other types.(ii)

Medium-run forecast covering a period from more than a year to two or four years. This helps the management to estimate probable profit and control over budgets, expenditure, and production. (iii) Long-run Forecast covering a period from one year to five years, depending on the nature of the firm. This type of forecast is utilized for adding new products and dropping old ones.

The traditional methods of sales forecast include time series regression, moving average (MA), Autoregressive Integrated Moving Average (ARIMA), and exponentials smoothing [1, 2]. ARIMA is a popular traditional method used to analyze stationary univariate time series data. The main idea of ARIMA is to build a mathematical model with historical data to represent the regular pattern of a time series. Then, using this model and historical values, forecast the future values of this time series. There are usually three main stages of building an ARIMA model, including model identification, model estimation, and model checking. Model identification is the most crucial stage in building ARIMA models [3]. ARIMA is the method introduced by Box-Jenkins and has been used in various fields [4]and this model is a great predictor in the linear modeling problems but has poor performance for nonlinear problems. The ARIMA model is a generalization of the ARMA model, which integrates an auto-regression (AR) and moving average(MA). Regression analysis is a method of investigating the relationships between variables while moving average is a time series constructed by taking the averages of severing sequential values of another time series.

Traditional time series methods may not be able to capture nonlinear patterns in data and hence are not accurate in finding the nonlinear relationship between inputs and outputs [5].In order to overcome the limitations of the traditional methods, many researchers are using artificial neural networks (ANNs).

In this paper, it is intended to give an introduction to the basics of ANNs and then to provide a brief review of the applications of ANNs in a few typical industries to know the current scenario and the directions for research to overcome the present limitations.

ARTIFICIAL NEURAL NETWORKS – A BRIEF OVERVIEW

An ANN is a computational nonlinear model based on the neural structure of the human brain. One of the specific features of ANNs is their capability to learn from examples to perform tasks such as classification, prediction and decision-making. [6]. an artificial neural network consists of simple processing elements, referred to artificial neurons. As shown in Figure 1, each neuron receives a number of weighted inputs from the neighboring neurons, the weights of each input depending on the strength of the respective interconnections. In the figure, w_1, w_2 etc. are the interconnection weights. Each neuron sums the received weighted inputs and is taken through an activation function. The commonly used activation functions are linear, step, sigmoid and tanh functions [6] as shown in Figure 2. An ANN consists of a large number of artificial neurons arranged according to some pattern of connectivity. An ANN essentially performs the computations in a parallel and distributed manner, receiving all the inputs at the same time and processing these inputs simultaneously to get the outputs. One of the most commonly used patterns of connectivity is referred to as multilayer feed-forward as shown in Figure 2. In this topology, the artificial neurons are arranged in layers. The first layer, which receives the external inputs corresponding to the problem to be solved is the input layer. The layer of neurons giving the output or solution vector is the output layer. There may be, generally, one or two layers in between the input and output layers. These are the hidden layers. The presence of hidden layers enables an ANN to solve non-linear systems. The number of hidden layers and the number of neurons in each of the hidden layers are problem dependent.

The number of neurons in the input layer is equal to the number of input variables and the number of neurons in the output layer corresponds to the number of output variables.

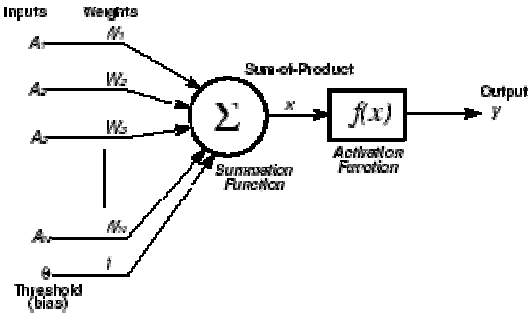

Figure 1: Artificial Neuron

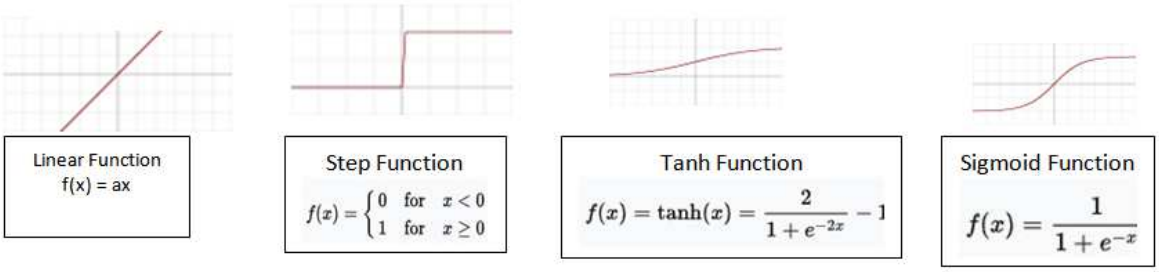

Figure 2: Typical Activation Functions in Artificial Neurons

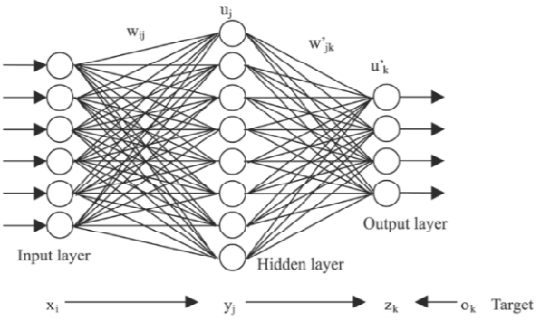

Figure 3: Multilayer Feed-Forward ANN

ANN training involves the determination of the interconnection weight matrices such that the forecast error is reduced to a minimum as per the specified accuracy. An error of predictions is minimized, and the network reaches a specified level of accuracy. The algorithms used for training the ANNs are referred to as learning algorithms. Various learning methods can be classified as [6-14]: (i) supervised learning algorithms (ii) unsupervised learning algorithms and (iii) reinforced learning algorithms. Supervised learning involves guided learning which requires a training pattern consisting of an input vector and the associated target vector corresponding to each input vector. The objective of unsupervised learning is to identify patterns in the input data through the clustering of input space. The system learns about the pattern from the data itself without apriori knowledge. In Reinforced learning, the expected answer is not shown, instead only indicates if the computed output is correct or incorrect. The information provided helps the network in its learning process. A reward is given for a correct answer computed and a penalty for a wrong answer.

Error backpropagation learning algorithm is a supervised learning algorithm, which is seen to be used by many of the researchers in various fields of ANN applications. The algorithm requires a number of input-output patterns prepared

either from experience or from simulation or measurements for training the ANN to perform a particular task. In the algorithm, first of all, the interconnection weights are randomly initialized. Then show the inputs of the first input-output set of the ANN. The ANN output so obtained is compared with the actual output corresponding to the first input-output set. The error value so obtained is propagated back from the output layer to the hidden layer and then from the hidden to the input layer. During this process, the initial weights will be updated such that the error is the minimum. This procedure is repeated for every input-output pattern and thus completing one iteration. The same procedure is repeated for the input-output sets. After many iterations, it can be noticed that the weight matrices get saturated and practically remaining constant irrespective of the input-output set. This is the indication of the completion of training. With the latest weight matrices obtained at the end of these iterations, the ANN can produce outputs within the desired accuracy for various input sets. The research in ANNs has been taken momentum in many fields, and these major applications [6] are as follows:

- Classification to predict the class of an input vector
- Pattern matching to produce a pattern best associated with a given input vector
- Optimization to find the optimal values of parameters in an optimization problem
- Control for an appropriate action based on given an input vectors
- Function approximation/times series modeling to learn the functional relationships between input and desired output vectors

ANN APPLICATIONS FOR SALES FORECAST

In this section, typical applications of ANN for the sales forecast in various industries are discussed.

Food Company

One of the major issues of food companies is because of their typical characteristics, such as (i) short shelf-life of the associated products, (ii) necessity to have high product quality and (iii) uncertainty and fluctuations in consumer demands. As the products get damaged because of their short-shelf-life, these can be kept only for a certain minimum time. Hence it can be observed that the surplus of food products leads to their wastage and hence loss of income. Similarly, if the shortage of the products also leads to loss of income for the company. The fluctuations in consumer demand happen because of the changes in their price, the proposed promotion schemes, the variations in consumer preferences or even weather changes.

Ref. [15, 16, 17, and 18] has proposed an ANN forecast model for fresh milk production plant. Fresh milk has a shelf-life of less than a week and at the same time; it is delivered and stocked on the shelves on a daily basis. In this paper, radial basis function (RBF) ANN [6] is utilized for the forecast of the daily sales volumes of fresh milk. The interconnection weights are optimized by means of a genetic algorithm (GA). The proposed ANN approach has been tested on the data of the fresh milk sales of one of the leading manufacturers of dairy products in Greece. The ANN method has been compared to many conventional time series methods, confirming the effectiveness of the proposed approach.

Fashion Industry

Fashion is a highly competitive industry. Sales forecasting is an indispensable part of the fashion industry. While long-term forecasts let the companies prepare for an upcoming season ref. [19-26], the forecast of short-term replenishment

requirement gives companies a competitive advantage. Precise forecasts can help companies maintain a lower inventory and still make sure that the products do not run out of stock. Short product life cycles, uncertainties in demand and wide varieties in designs make the forecasting process complicated. The demand for a particular category of clothing depends on the weather. For example, jackets and sweaters are sold more during late fall and winter. Similarly, the economic condition also affects the purchasing power of the consumer. Weather and economic parameters are also used in addition to the sales volume to forecast sales. In ref. [26] the average temperature is taken as an indicator of the prevailing weather. Similarly, total retail index for consumer goods and consumer price index for clothing and retail are used as indicative of the economic conditions.

Thus, in the neural network proposed uses 6 inputs –initial 3, 7 and 14 days sales volume, average temperature, retail price index for consumer goods and consumer price index for clothing and footwear. The model uses multi-objective evolutionary algorithm to optimize the input weights and biases. The model was tested on sales data from one of the largest retailers in Hong Kong and Main Land China. Investigations revealed that the proposed ANN forecast method shows a much superior performance compared to several popular forecasting models.

Publishing Industry

Convenience stores allow people to buy things at anytime and anywhere. They have a huge market and many publishing providers want to cooperate with them. Magazine businesses need plans for enhancing sales, distribution, storage space, and high-quality predictions. Accurate sales forecast can reduce inventory costs and shortages. It would increase profits for the business by reducing wasted resources and allow planning for appropriate future production. Most studies have depended on historical sales data for forecast sales, but the sales of magazines are also affected by the contents of the magazines. Publishing industries usually pick attractive titles and headlines for their stories to increase sales, since popular article titles and headlines can attract readers to buy magazines. In ref. [27], information retrieval techniques are adopted to extract words from article titles. The popularity of a title word is derived from the Google engine to determine how many webpage volumes they have related to the title word. The Google engine also can restrict results to a particular time frame, and the results can show the number of retrieved web pages related to the title word in a time window. Generally, more retrieved web pages for the title word indicate higher popularity. The search engine derives the popularity scores of title words by finding the number of web pages for each title word during a one-month search period before the publication date of each issue. We accumulate the popularity scores of all title words for each issue and use them to represent the popularity index of the issue.

The popularity measures of article titles are then analyzed by using the search indexes obtained from the Google search engine. Backpropagation Neural Networks (BPNNs) have successfully been used to develop prediction models for sales forecast. The proposed model uses the historical sales data, the popularity of article titles, and the prediction result of a time series. Autoregressive Integrated Moving Average (ARIMA) forecast method is used to generate the training patterns to learn the BPNN-based forecast model. Our proposed forecast model is experimentally evaluated by comparing with conventional sales prediction techniques. The experimental result shows that our proposed forecast method outperforms conventional techniques which do not consider the popularity of title words.

Retail Industry

Forecast of aggregate sales in the retail industry is very important for big retailers who hold a greater market share. Better and more precise forecasts of aggregate retail sales will aid individual retailers to better forecast their sales.

This is because there is often a pattern in the sale levels. For instance, retail sales of most stores increase over the Black Friday or Christmas. Furthermore, sales forecasting models of the major retailers, in most cases include industry-wide sales and their individual market share as inputs. Forecast of aggregate retail sales is also important for the government. It helps the government in developing public policies that are optimal for the retail industry. Another potential utility of the forecast is for portfolio investors who will be better equipped to understand the fluctuations in the stock market based on industry performance.

Ref. [28] proposes a multilayer feed forward artificial neural network model to forecast the aggregate retail sale. Further, ref. [28] uses this model to forecast aggregate sales in the US and compares it with more conventional statistical models to assess the performance of the proposed model. Sales data from Customer Business Report, Monthly Retail Trade: Sales and Inventories which is compiled by the US department of commerce are used as the input to train the artificial neural network model. It was found that the ANN performed the best among all the models tested. It was followed by Box-Jenkins and winter's exponential smoothing. Furthermore, it was found that the ANN could also capture the dynamic non-linear trend, seasonal patterns, and their interaction.

Supermarkets

Another important aspect that often demands precise forecasts at supermarkets is the weekly demand for its items. Supermarkets sell several products and an accurate forecast of short-term demands on its products can help the management save tremendously on inventory and supply chain. The main factor for the demand of a particular product is its price, advertising and promotions on that product. Furthermore, holidays also tend to increase the sale of products as it increases the customer inflow to these supermarkets [29, 30].

In ref. [29], a multilayer feed forward artificial neural network has been proposed. The network is trained using error backpropagation algorithm based on past data on sales amount, price, advertising campaigns and information on holidays. Extensive experiments were conducted on a set of items in a German supermarket. The forecast of the ANN was compared against commonly used methods for sales forecast in supermarkets. A comparison shows that the ANN model outperforms the conventional models in terms of the quality of forecast.

Audio Video Manufacturing Industry

It is good to understand the aggregate sales of a company. But for proper production planning, it is very important to know the distribution of this forecast among the different products. Ref. [31] looks into the problems faced by an audio and video manufacturing company – Bang Olufsen – in forecasting demand and sales for each of its products. The global competition, fast pace of product development, flexible manufacturing processes and an ever-growing number and variety of products make it even harder for the retailers and manufacturers to forecast product wise demand and to plan production. Hence a lot of firms resort to qualitative techniques for forecasting. These methods rely mainly on expert judgements and opinions, customer surveys. Historical similarities and decision from panel discussions. On the other hand, quantitative forecasting uses historical data to extrapolate and forecast the future.

In ref. [31], a three-stage model has been proposed. The proposed model sequentially filters output. The output of one stage is used as one of the inputs for the next stage. Some of the input parameters used include the month, previous year's total sale, sales two months ago, total sales in a specific region 12 months ago, bulk national product, consumer price index, and long-term interest rate. The first stage of the hybrid model is the winter's method. Backward stepwise

multiple regression following the first stage forms the second stage of the model. The final stage is a General Regression Neural Network model. General Regression Neural Network models are known for their ability to train on sparse data and still perform satisfactorily. The hybrid model resulted in a reduction of 2.3% of mean absolute percentage error with respect to conventionally used quantitative approach.

Automobile Industry

The automobile industry is one of the largest industries in the world. It hosts a great deal of human, time and financial resources. The automobile industry is highly reliant on future sales predictions. The better and more precise the forecast of future sales volume and car demand, the more optimized and efficient the investment volume, workforce recruitment, and time utilization can be. Furthermore, the prediction of demand and sales capability before manufacturing the desired car will give insights into whether investments should be made for manufacturing the car and what return such an investment will give Ref. [32, 33]. The main factors that determine the demand and sales of cars are economic aspects, the performance of the car, safety features available in the car, the comfort of the driver and the passengers, the body type of the car and its chassis and the seasonal effects based on the time of the year.

Ref. [34] proposes a multilayer feed forward artificial neural network. The first five of the inputs namely the economic aspects, the performance of the car, safety features available in the car, the comfort of the driver and the passengers, the body type of the car and its chassis were extracted from a questionnaire from the expert panel. The effect of season and month was taken from previous sales data. The data used in ref. [34] was obtained from KIA and Hyundai corporations in the US and Canada between 2010 and 2015. Error backpropagation was the learning algorithm used. It was concluded that the proposed neural network model is able to efficiently predict the trend of car sales based on the input parameters fed in. A comparison with conventional methods for sales forecasting such as linear and exponential regression shows that results obtained from the neural network model is far superior and closer to the actual values.

Fast Moving Consumer Goods

Fast Moving Consumer Goods (FMCG) or Consumer Packaged Goods (CPG) is products of the relatively low cost that are sold quickly at stores. FMCGs have a relatively short shelf life. This is either because the products deteriorate quickly or have high customer demand. Some of the examples of FMCGs include soft drinks and personal care items. Even though profit margins on such fast-moving consumer goods are low, large sales volume of these products makes the cumulative profits substantial. Forecasting of sales is a part of downstream activities in a supply chain. It is a process or predicting demand and sales of a product in the future based on knowledge from previous data. This helps in making informed decisions to optimize the supply chain and inventory. A Sales forecast is important for Fast Moving Consumer Gods owing to the high volume of sales. Any deviation in the prediction from the actual data will result in huge losses either due to the product going out of stock or inventory expenses caused by overstocking. This warrants a precise model to accurately forecast demand for these items.

In ref. [35], a multi-layer artificial neural network has been proposed to predict sales of oral care products. The learning algorithm used in ref. [35] was an errorbackpropagation algorithm. It was found that the artificial neural network model gave a forecast very close to the actual sales. This was validated based on Mean Absolute Deviation (MAD), Mean Square Error (MSE) and Root Mean Square Error (RMSE). In all the evaluations, the neural network model used in ref. [27] consistently excelled.

CONCLUSIONS

In this paper, the research and developments in the application of ANN for sales forecast in typical industries have been discussed. The ANN applications for the sales forecast in the following industries have been reviewed: Food Company, Fashion Industry, Publishing Industry Retail Industry, Supermarkets, and Audio Video Manufacturing industry. The review of typical papers in the field indicates that the ANN can be effectively used for sale forecast.

The effectiveness of ANN can further be enhanced through the utilization of the other soft computing paradigms, the fuzzy logic and the genetic algorithm concepts in developing the ANN for the sales forecast. Further investigations are required in this direction. In addition, in certain cases forecast may become inaccurate whatever be the type of ANN that is used for the purpose. The failure may be due to the following factors:

- Change in the general trend in style and fashion: If a company does not monitor these changes and incorporate these observations into the sales forecast model, then the forecast may become misleading.
- Lack of sales history data: In the absence of sales history records, the sales forecast would be performed on assumed data, and thus leading to erroneous results.
- Consumer Behavior: The attitude of the consumers may get changed so suddenly that is unpredictable.
- Public Appeal of the company: For instance, even rumors can have adverse effects on the sales of certain products.

Hence further research is required taking into account these factors while developing ANNs for more accurate sales forecast of any industry. Precise forecast of sales can help in knowing how much inventory to keep meeting the demand while making sure that the inventory maintenance charges are low. In addition to inventory cost, the order cost also has to be considered to make sure that the overall cost for the supply chain stays low. The order quantity and the interval between the two orders are very crucial in this regard. The forecast for sales fill gives the demand of the product. This can be used as an input. We can develop ANN models that take the inventory maintenance cost, the transportation cost, order cost, delivery time, and life of the product to optimize the order quantity and the interval between two subsequent orders. Furthermore, using the genetic algorithm in conjunction with ANN can be used to improve the performance of the model. Another aspect of forecasting that can potentially make use of the forecasting capability of ANN is the transportation industry. The traffic volume can be estimated using the ANN model. This forecast can be used for dynamic pricing on tollways.

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