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A Conceptual Comparison between Neural Network and Forecasting Technique in Market Research

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Abstract:
The forecasting technique is used to predict future demand for a product or services. Forecasting is used in process design, capacity and facility planning, aggregate planning, scheduling, inventory management etc.The paper concentrates on multiple regression analysis method to solve forecasting problems. In this paper we have made an attempt to compare statistical technique with Neural Network to forecasting.

I. INTRODUCTION:

From time immemorial many discoveries have been made to cater the services of the mankind. In the early days all the mathematical calculations are made manually by human brain. Due to the development of science and technology many sophisticated machines have been invented to reduce the tedious exercises in order to solve the complex nature of the problem to make the life smooth, happy and comfortable. Artificial neural network has a wide range of applicationin the field of pattern recognition, image processing, medicine, optimization in the industrial engineering and other related fields. Neural Network able to specify the patterns in the data, which is used in statistical analysis. So by White [25] Neural Network is considered as a statistical tool. Hence in current days Artificial Neural Network is popular in business solutions.

In this present paper we have compare the Artifitial Neural Network and Statistical Technique. The organization of this paper is as follows: Followingtheintroduction, in section 2 overview of Neural Network is given. In section 3 we discuss application of ArtifitialNeural Network for solving forecastingproblems. The paper concluded with some remarksin section 4.

II. OVERVIEW OF ARTIFITIAL NEURAL NETWORK:

The invention of calculator due to Abacus which is in the form of wooden frame consisting of sliding beads in the wires helped in counting Arabic numerals by the Fisherman, Merchants and Clarks. Subsequently in the year 1623 WilhermSchickand developed an arithmetic calculator called calculating clock simplified the day to day calculation. During the year 1643 the French philosopher Blaise Pascale built the arithmetic calculating device called Pascaline which is considered as the first calculating device used in Tax calculation in France till 1799.In the year 1822 the difference engine due to Charles Babage helps to simplifies the operation on numbers up to 31 decimals degits in the Arithmetical Calculation. The modified machine due to George Scheistz which is a piano like structure can able to create logarithmic table which was demonstrated at the exposition universelle in Paris in 1855.Due to the constant effort of scientist such as MartinWiberg (1875),DorrE.Felt (1884), William.S (1891), HowardAiken (1938), AtanasaffBerry (1942) and J.PrisperEcket and John Mauchly (1946) many changes have been made in calculating device. During the period of world war II,though John V.Atansoff a professor of physics and Clifford E.Berry a graduate student at Iowa State College started constructing an electronic computer but unable to completeit. However due to the constant attention in this regards Atansoff Berry completed the same in 1939 and used in the work. The machine Electronic Numerical Integrator and Calculator(ENIAC) invented by J.Presper Eckert and WilliamMaavchley which is big in size containing 18,000 vacuum tubes could able to perform Arithmetical calculation at therate 5000 addition per second helps in solving mathematicalproblem. Impressed upon the work of Charles BabageandGeorgeScheistz, John Van Neuman invented firstdigital computer which is named as first generation of computergives immense help to the mathematician, scientist and technologiesfor the various research work.

The machine designed in the Bell Laboratory during 1947 by usingtransistor put a remarkable change in the evolution of calculatingdevice and it is called as second generation of computer. Duetoconstant research in this direction in the year 1956 a newcomputer called **Leprechaun** built in Bell laboratory usingintegrated circuits could able to improve machine for betterform. The microprocessor was a large scale integrated circuit whichcontains thousands of transistors and the transistors on the chipwere capable of performing logical and

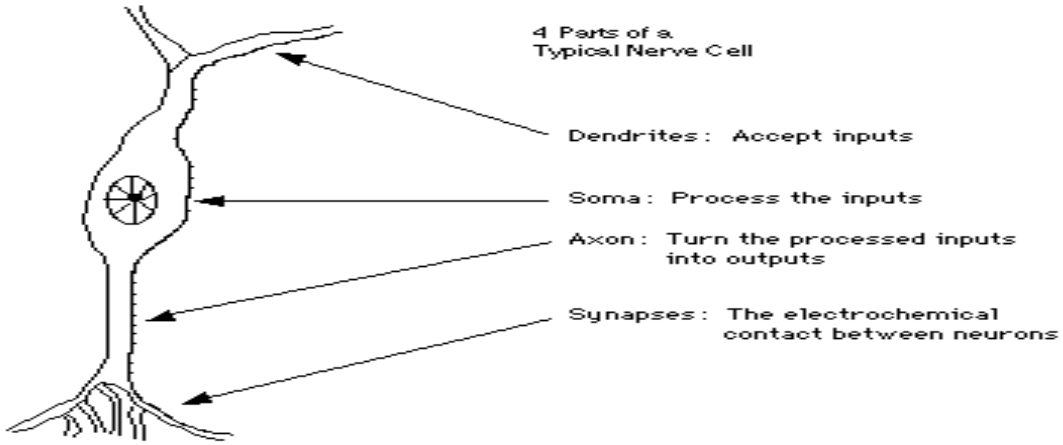
mathematical calculationcalled central processing unit. The reduced size, reduce cost andincreased speed of the microprocessor led to the creation of thefirst personal computer. The first Apple computer due toSteveJops and Steve Wozniak (1976) andsubsequently by IBM (1981) made a revolunary changes in theinvention of personal computers which has a great impact on thesociety. Subsequently the uses of Silicon chips enable the scientistto indent the machines and in 1971, Intel designed micro computerusingmicroprocessor. Now a day's researcher trying to developintelligent machines to solve the complex natureproblems. Artificial neural systems are examples of such machinesthat have great potential to improve the quality of ourlife. Traditionally the term neural network has been used to referto a network or circuit of biological neurons. The modern usage ofthe term refers to artificial neurons or nodes. Thus the termNeural Network has two distinct usages. Biological neural networksare made up of real biological neurons that are connected orfunctionally related in the peripheral nervous system or thecentral nervous system. In the field of neuroscience they are oftenidentified as groups of neurons that perform a specificphysiological function in laboratory analysis.

In general biological neural network is composed of a group orgroups of chemically connected or functionally associatedneurons. A single neuron may be connected to many other neurons andconnections in a network may be extensive. Neural network isdefined as a simplified models of the biological neuron system isa massively parallel distributed processing system made up ofhighly inter connected neural computing elements that have theability to learn and there by acquire knowledge and it is able foruse in different problems. Various learning rules are adopted foracquiring knowledge for better efficiency. Neural network isclassified due to its learning mechanism and other features.

Artificial neural networks are made up of interconnectingartificialneurons. Artificial neural networks may either be usedto gain an understanding of biological neural networks or forsolving artificial intelligence problem without necessarilycreating a model of a real biological system.

The concept of neural networks was worked upon in the late1800(19th century).It was an effort made by the researchers tounderstand the functioning of human mind. The pioneering work McCulloch and Pitts [13] in 1943 put a foundationstone for the beginning of the golden era in the field of neuralnetwork and he considered as the father of Artificial NeuralNetwork. These models are based on several assumptions on thefunctioning of neurons as there was not much known about thefunctioning of neurons. Their networks were based on simpleneurons, which were considered to be binary devices with fixedthresholds. The results of their models were simple logic functionOR and AND such as "X or Y" and "X and Y".In late 1940'sDonald Hebb [8] made an first hypothesis forneuralplasticity (learning low neuronal connections are enforcedin mammalian brains).This is also a technique of weight selectionin artificial neural network which helps in training the neuralnetwork. In early 50s Friedrich Hayek was the first tocome out with the idea of spontaneous signals arising due todecentralized network of neurons. The suggestion due to VonNeuman [23]in his papers for design a brain likeprocessing unit subsequently helps Neumann [14]to designe a new technology for the construction of electronicdiscrete variable automatic computer which is developed out ofelectronic numerical integrator and the machine so designed wasthe first general purpose electronic computer which was built atMoore school of Electrical Engineering of University ofPennsylvania with somecorrection due to Aspray and Buck [1].

Human brain serves as an information processor in the humanbody. Many researchers use the structure, function and theassociation of the human brain as a model for building intelligentmachine systems, still there is not much information available onthe functioning of human brain. It is believed that the brain cellshelp us think related things and memorize. The struggle tounderstand the brain has been made easier due to the pioneeringwork of RomonCajal[18] who introduced the ideaof neurons as structural constituents of the brain. Abrainconsists of 10^{10} basic units called neurons. A neuron is asmall cell that receives electro chemical signals from its varioussources and in terms responds by transmitting electrical impulsesto other neurons. A neuron is composed of a nucleus of a cell bodyknown as soma. The signals generated in soma are transmitted toother neurons through an extension on the cell body called axon ornervefibres.Another kind of extensions around the cell body likebushy tree is called dendrites which are responsible fromreceiving the incoming signals generated by other neurons byNokes [15].The incoming signals are processed bysoma and then the soma converts the processed signals into anoutput. Theaxons from two different neurons meets in a gap calledsynaptic gap containing synaptic fluid which regulates the signalsgenerates different neurons to improve the signals given in thefollowing figure.



(Fig 1.Part of Typical Nerve Cell)

After studying 25 years about the system of nervous systemneuro-physiologist Walter MC-Culloch and Yang mathematical prodigyWalter Pitts wrote a paper on how neurons mights work and hencethey built a primitive artifitial neural network using simpleelectricalcircuits. The theory developed by them is called asMCCulloch-Pitts [13]theory of formal Neural Networkwhich is a major area in the information technology in the 21stcentutry.According to MC Culloch -Pitts model. An Artificial neuralnetwork is an information processing system that has certainperformance characteristics in common with biological neuralnetworks. Artificial neural networks have been developed asgeneralization of mathematical models of human cognition of neuralbiology based on the following assumptions:

(i)Information processing occurs at many simple elements called neurons.

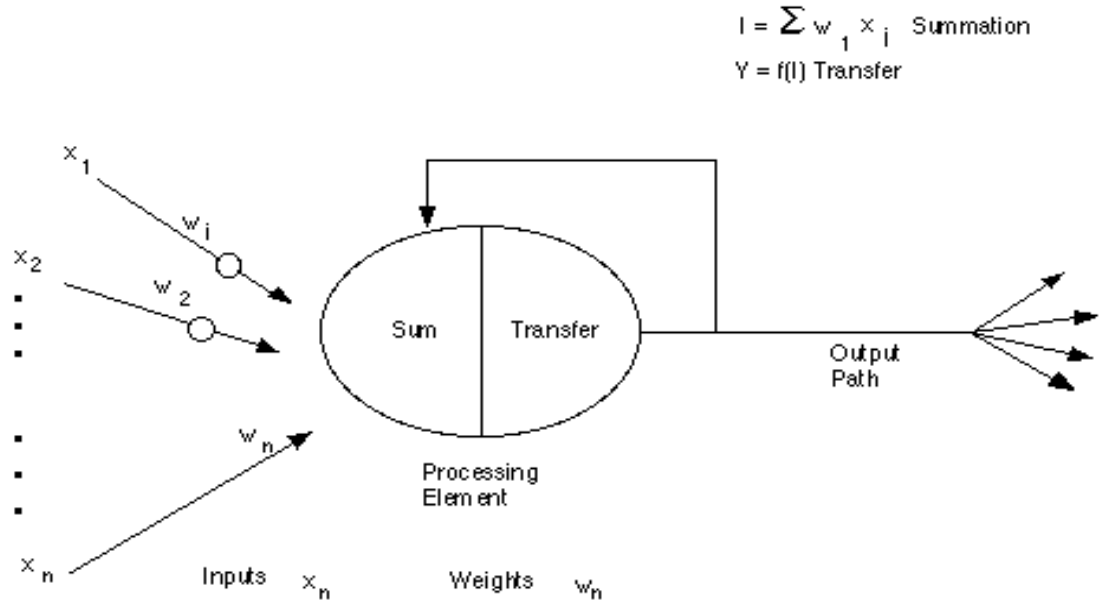
(ii)Signals are passed between neurons over connection links.

(iii)Each connection link has associated weightswhich, in a typical neural net, multiply the signal transmitted.

(iv)Each neuron applies an activation function (usuallynonlinear) to its net input (sum weighted input signals) todetermine its output signals.

A neural network consists of a large number of simple processingelements called neurons or nodes. Each neuron is connected to otherneurons by means of directed communication links each with anassociated weight. The weights represent information being used bythe net to solve problems. Each neuron has an internal state calledits activation or activity level which is a function of the inputsit has received. Typically a neuron sends its activation as asignal to several other neurons and a neuron only send one signalat a time.

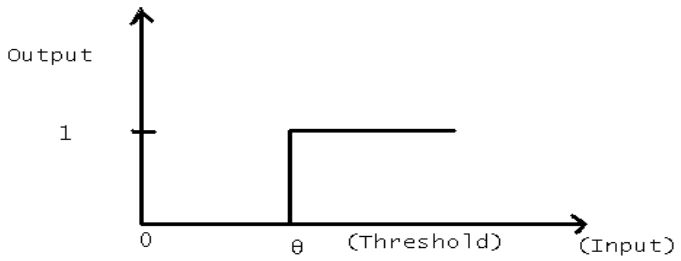
Let us consider $x_1,x_2,...x_n$ are n input signals to aalong with corresponding weight $w_1,w_2,....w_n$.Asthebiological neurons receives all inputs through dendrites sum themand produce an output if the sum is greater than a threshold valuein the similar fashion if the weighted sum is greater than athreshold value then it give an output to the next neuron.



(Fig 2. Artifitial Neural Network)

Let I be the total input received by the soma of the artificialneuron given by
$I=w_1x_1+w_2x_2+....+w_nx_n=\sum w_ix_i$
If 'Y' be the final output of the neuron then
$Y=\Phi\ (\sum w_ix_i-\theta)$
where$\theta$is the activation function and θbeing thethreshold value.
The output 'Y' can be given as discrete which is given by

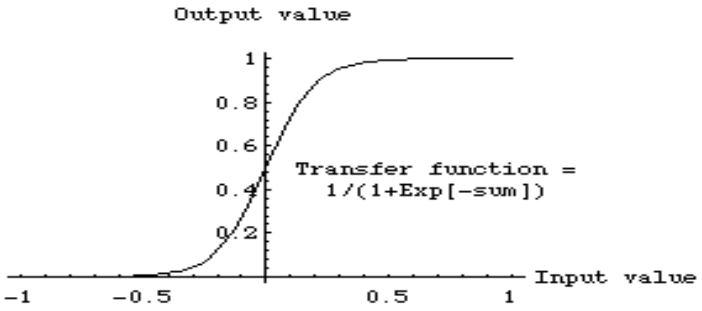
$$Y= f(x) = \begin{cases} 1, & I > \theta \\ 0, & I \leq \theta \end{cases}$$



(Fig 3.Threshold Function)

The continuous activation function called sigmoid function has agreater role in neural network which is given by

$\Phi\ (I) = \frac{1}{e^{\propto I}}$
where 'a' is the slope parameter of the sigmoid function.

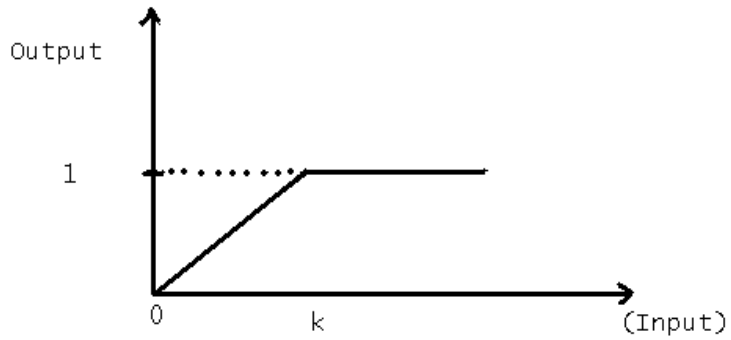


(Fig 4.Sigmoid Function)

which adjust the abruptness of the function between the twoasymptotic values.
The other activation function such as linear type given byf(x) =kx, k being the real constant and ramp function by

$$f(x) = \left\{ \begin{array}{ll} 0 & , \ x \leq 0 \\ \frac{x}{k} & , \ 0 < x \leq k \\ 1 & , \ k < x \end{array} \right\}$$

is used in the different problem of neural network.



(Fig 5.Ramp Function)

III. ARTIFITIAL NEURAL NETWORK FOR SOLVING FORECASTING PROBLEMS:

Forecasting is to predict what is most likely to happen in the future. So a manager takes effective decisions and makes planning for future activity. In the past astrologers and psychics provided us with guidance about the future – from when to plant crops to when to go to war. But in recent days we have powerful computers and statistical software and elaborate acronymed processes. So we easily predict the future. The main objective of forecasting is to predict future demand for a product or services. Forecasting is used in process design, capacity and facility planning, aggregate planning, scheduling, inventory management etc.The multiple regression analysis is the commonly used method used in forecasting. In this section we discuss about uses of regression analysis and neural network for solving forecasting problems.

Multiple Regression Analysis: Multiple regression analysis is a methodto define the relationship between a dependent variable and one or more independent variables. In the case of a product that is sold to a final consumer, MRA calls for determining the quantitative relationship with the following variables for determining retail sales forecasting:

$Y = f(X_1, X_2, X_3, X_4, X_5, \ldots)$

where, Y =Market demand for the product
X_1 = Consumers' disposable income
X_2 = Population size
X_3 = Product price
X_4 = Substitutes price
X_5 = Complementary products price
The manager must specify a family of equations in the form of regression curves and select the member of the family that best fits the data. The quality of fit is measured in terms of an error term. Normally the least square method is used to fit the equation.

Difficulties in Regression Analysis:

The requirement of a priori knowledge of the functional form is a major difficulty in using regression analysis. So the decision maker must know about a priori the form of equation. Generally the prior knowledge of the form of the equation is difficult to finds out. Otherwise the decision makers built several functional forms and lastly choose a single functional form which is fits to the available data. Sometimes the decision makers face the problem to decide which functional form is best to the data. So a market researcher or decision maker finds out the linearity in a data structure. Hence the models can be built easily. But the linear models are not good in the case of picking up turning points in the available information. For example a marketing manager always deals with sales and price data but the data series must have turning points, trends and nonlinearity. Sometimes it may be chaotic (Thall [22]).Excluding these problems several methodological problem are involved in regression analysis such as multicollinearity and heteroscedasticity.

The conventional multiple regression analysis deals with single dependent variable at a time. Forexample, Let a manager is interested in predicting profit besides cash flow, then two cases are arised.When multiple factors are to be predicted, canonical correlation can be applied. But it is onerous to interpret the results of such an analysis and the methodology does not lend itself readily to making predictions (Proctor [17]).Neural networks do, indeed, avoid these particular problems and can be of use to marketing managers to forecastsales.

Neural Network Approach to Prediction of Retail Sales Forecasting:

A network can be constructed in which the number of independent variables is equal to the number of nodes at the input layer, and the number of nodes at the output layer is equal to the number dependent variables. The number of hidden layers and the nodes in each hidden layer can be selected arbitrarily. To develop the internal representation at lease one middle layer is present to define relationship between the variable. So better result may be expected with the neural network when it is not fit to the assumed model. Hence neural network at least one hidden layer is sufficient to approximate any continuous function.

The middle layer nodes permitting the network to give reasonable generalizations. In general the number of nodes in the hidden layer was taken to be at least 75 per cent of the number of input nodes. The structural feature of the neural network is given in Figure 6.In this case the network can be trained using the back propagation algorithm (Burke [3]).

The neural network in Figure 6 consists of five nodes ac input layer, each of which represents X_1, X_2, X_3, X_4 and X_5. A hidden layer is present having four nodes; and an output layer is present having two nodes, and it represents retailer sales forecasts and time taken to break even. Signals in the neural network flow in the feed forward network from left to right. The network performs two operations, one at the hidden layer and another one at the output layer.

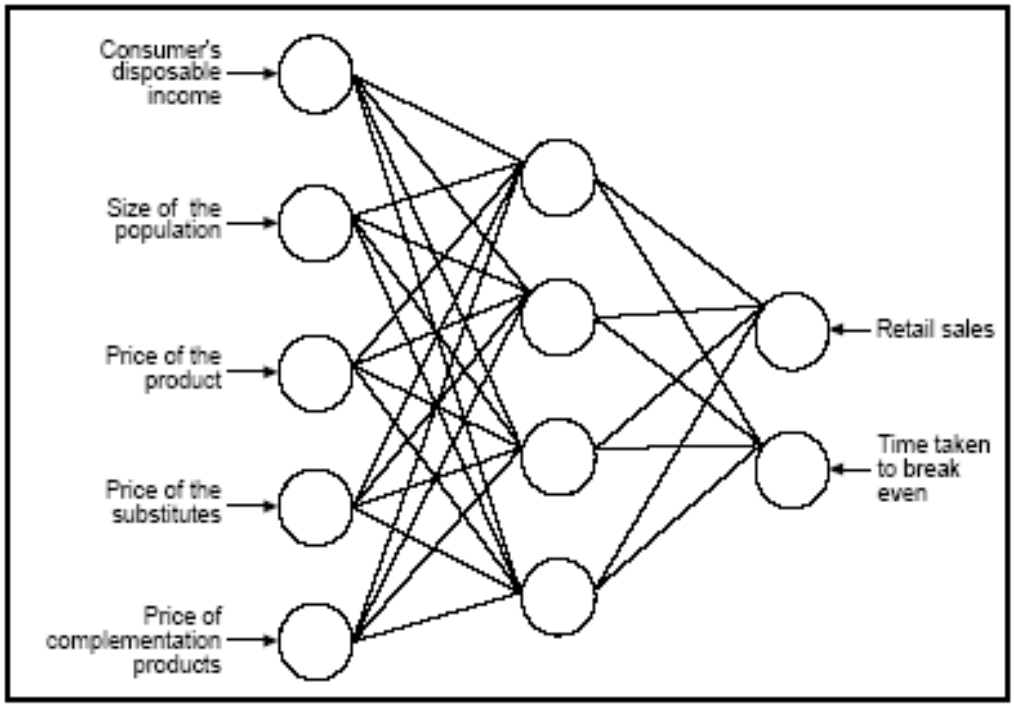


Fig. 6(Neural Network for retail sales forecasting)

The data on the independent factors are size of the population, price of the product and consumers' disposable income, and the data on the dependent factors are sales and time taken to break even, form a signal. The arbitrary values assigned the weights of the network. Each case from a sample can be loaded on to the input layer of the network. The input nodes send these values to the hidden nodes. Each hidden node calculates the weighted sum of the inputs given using the weights assigned to the connections. Each hidden node squashes the sum value down to a limited range and sends the result to output nodes. Each output node works a similar calculation. The result of the calculation is the value of the dependent variable, viz., sales and time taken to break even and output nodes are given actual/observed value(s) of the dependent variables for that case. According to difference between the computed value of the dependent variables and observed values of the dependent variables, each output node determines the direction in which each of its weights would have to move to minimize the error, as well as the amount of change that would be made, and this is propagated to a hidden node. The hidden nodes use these errors to determine in which direction and by how much they should change their weights, just as the output nodes did. This procedure is said to be trainingand it is repeated over and over again to the network, enabling the network to adapt its weights so that the estimated cash flow and profit reflect its actual value. This process is measured by an error calculation that is the difference between the estimated sales and the time taken to break even and its actual value summed over all signals. The objective of training is to minimize the error in all signals. After sufficient training, the network should be able to forecast. This can be tested with test data. In training new facts composition is not used. With this idea, and with the help of neural network software tools such as Explorenet,managers can use a neural computing tool for their decision-making process.

The neural network approach forecasts retail sales by modeling the relationship between the independent factors and the dependent factors. Neural network methods are non-parametric in the sense that functional form are not be specified a prioirather than relying on a prespecified functional form, neural networks build their own model by "learning", testing and modifying. Neural networks change their weights as new input data become available, thus adjusting readily to a changing environment. A traditional regression method is not adaptive but typically processes all data once again together with the new available data. In neural networks, activation of each neuron is aindependentlinear combination. Thus neural networks, being the collection of neurons and define complex relationships. So neural network handle non-linear/chaotic data series by deriving a suitable map between high-dimensional input pattern spaces and output.Differentmethodological problems, such as multicollinearity and heteroscedasticity, are involved in the regression analysis. The conventional multiple regression equation deals with only one dependent factor at a time. Suppose the managers are interested in predicting the time required to break even, then these two cases are to be dealt with separately. But a neural network can deal with more than one dependent factor at a time. The other feature of neural

networks is, if some of the data are missing, the networks generalize across gaps by building up a model and interpreting it owing to its fault-tolerant nature. Neural networks perform well with missing or incomplete data, which is most difficult for regression analysis. A single missing value in regression analysis calls for dropping the entire observation or dropping the variable from all observations. So, the statistical significance of the model parameters in neural networks is not needed. Testing the network is same as cross-validation in the regression.

Different Researchers have studied the performance of ANN in forecasting analysis. De Groot and Wurtz [5] have compared neural networks with standard non-linear models and concluded that neural networks are the best when the data exhibit non-linear characteristics. White[25] has found out the similarity between the back-propagation method and stochastic approximation method. The study of Weiss and Kulikowski [24] has tested a back-propagation model and concluded that the model is performed well for regression applications.

IV. CONCLUSION

Neural networks can be applied to several marketing decision-making problems which were once reserved for multivariate statistical analysis. Both neural networks and statistical techniques have common goals, there are many differences between these two techniques. The major difference between neural networks and other statistical procedures is the method of processing data. In statistical techniques, processing of the data is by batch and is sequential and the data are used only once but in neural networks, each data in the sample is presented to the network repeatedly until the network identifies or learns the association of input to output and this repeated processing takes place in a parallel and distributed way. Many processing elements share the job of working out the results.

Neural networks are capable of identifying the relationship, whereas regression analysis requires knowledge of the nature of the underlying relationship. Another important thing in neural networks is that they are fault-tolerant. This means that the contribution made by any single processing element is not too important. Hence, even when there are missing elements in the sample data, the result/performance of the neural networks is not affected in a significant way. But, in statistical methods, problems with missing data are treated differently. For example, certain analysis requires correction terms to be added whenever there is a missing element. This correcting term is based on the number of missing elements. The neural networks can estimate both quantitative variables (interval and ratio scale variables) and class variables (nominal variables), the same neural network and learning algorithm can be used for forecasting purposes and limitations of neural networks distinguish them from statistical techniques. Formulae have been developed to find out the sample size for a given desired accuracy in statistical techniques. But there is no hard-and-fast rule in determining the sample size for training neural networks. So a sample of larger size would lead to high accuracy, whereas a smaller sample would lead to low accuracy. When there is a severe constraint on sample size, one should increase the number of iterations to improve efficiency.

In general, we can say that neural network approaches differ from traditional statistical techniques in several ways, and the differences can be exploited by the application developer. They are powerful alternative tools and a complement to statistical techniques when data are multivariate with a high degree of interdependence between factors, when the data are noisy or incomplete, or when many hypotheses are to be pursued and high computational rates are required. With their unique features, both methods together can lead to a powerful decision-making tool. Studies and investigations are being made to enhance the applications of ANNs and to achieve the benefits of this new technology.

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