Cash Demand Forecasting for ATM using Neural Networks

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Abstract- Automatic teller machine (ATM) is one of the most popular banking facilities to do daily financial transactions. People use ATM services to pay bills, transfer funds and withdraw cash. Accurate ATM forecasting for the future is one of the most important attributes to forecast because business sector, daily needs of people are highly largely dependent on this. In recent years, Neural Networks have become increasingly popular in finance for tasks such as pattern recognition, classification and time series forecasting. Every financial institution (large or small) faces the same daily challenge. While it would be devastating to run out of cash, it is important to keep cash at the right levels to meet customer demand. In such case, it becomes very necessary to have a forecasting system in order to get a clear picture of demand well in advance. In this research article an integrated BP/GA technique is proposed foraccurate ATM forecasting. The results are very encouraging. The comparison of proposed technique with the previous one clarifies that the proposed model outperforms the previous models.

General Terms- Neural Networks, Artificial Intelligence.

Keywords- ATM Forecasting, ANN, Back propagation Algorithm, Genetic Algorithms, Hybrid Techniques.

I. INTRODUCTION

ATM is a computerized telecommunication device that provides a financial institution's customers a method of financial transactions in a public space without the need for a human clerk [2]. Most ATMs are connected to international bank networks, enabling people to withdraw and deposit money from machines not belonging to the bank or country where they have their account. Automated Teller Machines are one of the most important cash distribution channels for the banks [11].

Bank customers are able to do their regular transactions such as bill payment, transfer funds and cash request without worrying about banks' working days, business hours, etc. One of the primary concerns with ATM management is to determine the efficient level of cash inventory in each machine and there are different techniques offered to handle this problem [3].

Forecasting is a phenomenon of knowing what may happen to a system in the next coming time periods. For financial institutions, providing an adequate supply of currency to meet customer needs is a continual challenge. Running out of cash at an ATM or other location means reduced revenue from lost surcharge fees and increased expenses due to emergency currency deliveries. But overstocking currency means banks can't invest this non-earning asset to generate interest income [10]. The ability to predict the future demand estimate of cash for automatic teller machines (ATMs) called ATM forecasting. The primary objective of ATM forecasting is to ensure that cash is used efficiently and effectively throughout the branch network [9].ATM forecasting and services availability is one of the most important factors in the ATM network services business. Using ATM cash management optimization and efficient cash loads routing, banks can avoid of stuck ATMs with cash and manage the system in dynamically changing environment by achievement the different requirements of ATM network participants. Recently, more banks are turning their attention to derive greater efficiency in how they manage their cash at ATMs [2].The key to the ATM's forecasting algorithms is to capture and process the historical data such that it provides insight into the future. Newly, some authors attempted to optimize the cash by modeling and forecasting the demand [3]. However, the high variance and non-stationary of the underlying stochastic cash demand process can affect reliability of such approaches. Furthermore, the demand of cash is not only influenced by time, but it follows different tendencies that make modeling even more difficult. For example, holidays, weekends, starting of month, festival days etc. [2].

The remainder of the article is organized as follows. Section 1 introduces the ATM forecasting. Next, a brief description of ANN, BP and GA is given in Section 2, Section 3 and Section 4 respectively. The details of the integrated BP/GA technique for ATM forecasting model are shown in Section 5, followed by results and discussions in Section 6. Finally, Section 7 contains the summarized conclusions.

II. ARTTFICIAL NEURAL NETWORKS

Artificial neural networks provide a methodology for solving many types of non-linear problems that are difficult to solve by traditional techniques. Essentially, an artificial neural network can be defined as a pool of simple processing units (neurons) which communicate among themselves by means of sending analog signals. These signals travel through weighted connections between neurons. Each of these neurons accumulates the inputs it receives, producing an output according to an internal activation function. This output can serve as an input for other neurons, or can be a part of the network output. Neural Networks have three building blocks- Learning Mechanism, Neural Network Architecture and Activation function [14].

III. BACK PROPAGATION ALGORITHM

One of the most popular training algorithms in the domain of neural networks used so far, for ATM forecasting is the back propagation algorithm (BPN). It is a gradient descent method. The algorithm suffers from several problems, like the local minima problem, scaling problem, non-suitability for complex problems [13].

IV. GENETIC ALGORITHM

Genetic Algorithms developed in 1970 by John Holland, are computerized search and optimization algorithm that mimic the principle of natural genetics and natural selection. Genetic Algorithms perform directed random searches through a given set of alternatives to find the best alternative with respect to given criteria of fitness. Fitness is defined as a figure of merit which is to be either maximized or minimized. An initial population of chromosomes (set of strings) is taken to generate offspring (from fit parents) that competes for survival to make up the next generation of population [4]. As compared with BP, Genetic Algorithm is a parallel stochastic optimizing algorithm and is good at global searching (not in one direction). Also it works with a population of points instead of a single point. It is a population based search algorithm and multiple optimal solutions can be captured thereby reducing the effect to use the algorithm many times [5]. Secondly, Genetic Algorithms work with a string coding of variables instead of the variables. The advantage of working with a coding of variables is that coding discretizes the search space even though the function may be continuous. Thus, a discrete function can be handled with no extra cost. Also Genetic Algorithm can be applied to a wide variety of problems. So always the solution gets better with time [6] [7].

The price one pays for Genetic Algorithm is its slowness. The slowness is mainly due to the slow but crucial exploration mechanisms employed, which has three basic arithmetic operators: reproduction, crossover and mutation. In addition, Genetic Algorithm starts searching from random genes, which will cost a lot of time [1] [5].

V. INTEGRATED BACK PROPAGATION BASED GENETIC ALGORITHM

In this section the features are integrated of both the techniques. The proposed ATM forecasting model based on BP/GA technique starts with the collection of ATM related data, selecting the ATM parameters , formation of training data set (containing inputs and outputs) and testing data set (containing inputs). Finally the methodology and its simulation are provided.

Several attempts have been made by various researchers to solve these problems using genetic algorithms, the computerized search and optimization algorithms that mimic the principle of natural genetics and natural selection by developing hybridized approach, but, in the field of ATM forecasting, such efforts are still to be put up. Hence there is an immense need of an ATM forecasting model which will not only work to keep cash at the right levels but also try to eliminate the problems incurred in gradient based back propagation algorithm through genetic algorithms. So, the motivation of this work is firstly, to integrate back propagation with genetic algorithm in such a way that the disadvantages of the algorithm get converted to benefits, used further for an accurate ATM model and secondly, to perform comparison between the two main techniques- back propagation network based on gradient descent technique and back propagation network based on genetic algorithm to train the neural network. The comparison also shows the importance of hybrid technique in the field of ATM forecasting with respect to the results using MATLAB R2009a.

a. Proposed Model

In this section, the features of back propagation algorithm and genetic algorithms are integrated. The proposed ATM forecasting model based on hybrid neural network approach is described with the collection of ATM related data, normalization of data, feature extraction, training and testing as shown in Figure 1.

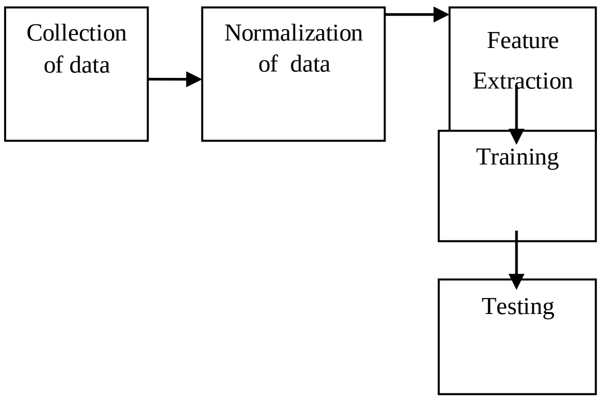

Fig.1: Steps to design hybrid ATM Forecasting Model

i. Collection of Data

In this phase, ATM related past data is collected which contains detail of total amount withdrawn along with dates.

ii. Normalization of Data

After the collection of data, next issue is the normalization of data. Neural networks generally provide improved performance with normalized data. The use of original data to network may cause convergence problem. All the ATM data sets were, therefore, transformed into values between 0 and 1 by dividing the difference of actual value dt and minimum value dmin by the difference of maximum value dmax and minimum value to obtain the normalized data dnorm as follows[12]:

$$d_{norm} = \frac{d_t - d_{min}}{d_{max} - d_{min}}$$

The main goal of normalization, in combination with weight initialization, is to allow the squashed activity function to work at least at the beginning of the learning phase. Thus, the gradient, which is a function of the derivative of the nonlinearity, will always be different from zero. At the end of the algorithm, the outputs are de-normalized into the original data format for achieving the desired result.

iii. Feature Extraction

The data collected at data collection step, was in the raw form. It was processed and analyzed manually to extract five features namely day number, week day, weekend effect, salary effect and holiday effect obtained from the study of past data as shown in Table 1.

Day number is kept for reference of the day of the month, week day means the day of the week, weekend effect is 1 for Saturday, 2 for Sunday and 0 for the other week days, salary effect gives the effect of salary on ATM usage. It is set 3, 2,1 for three consecutive days after the salary is being credited into accounts and is 0 for normal days, Holiday effect accounts for the holidays other than the weekends. It is 1 for a holiday and 0 for working day. If there appears two or more holidays consecutively, then the effect goes up. With each holiday, a one is added to the effect. Say, for 3 consecutive holidays, it is 1 for first day, 2 for the second and 3 for the last day.

Table 1:Input variables for ATM Forecasting

S.No.	Input Parameters
1.	Day Number
2.	Week Day
3.	Weekend Day
4.	Salary Effect
5.	Holiday Effect

iv. Training

This network is trained using backpropagation and Hybrid (BP/GA) algorithms along with collected data. The effects of different parameters are also considered in this phase.

v. Testing

After the training phase, testing is done with the set of weights obtained during the training phase. In this, inputs are fed to the network along with the final weights and the outputs are obtained thereafter. Weights are basically according to the importance (effect) of different parameters on ATM forecasting.

VI. RESULTS AND DISCUSSIONS

ATM forecasting technique based on BP/GA technique has been implemented by taking different population sizes.

Table 2: Selection of appropriate NN architecture

Population Size	Hidden Neurons	Iterations	MAPE
30	1	190	1.10
60	2	340	0.86
90	3	400	0.42
120	4	482	1.47
150	5	525	1.85

For each value of population, the program has been executed and the error has been calculated. Table 2 shows the variations in population size, number of neurons in hidden layer and the corresponding mean absolute percentage error values. From the table 2, it is clear that the MAPE value is the lowest corresponding to population size 90 and number of hidden neurons as 3. So the present setup will use this population size for further research. The error vs. iteration graph corresponding to population size 90 is shown in fig. 2.

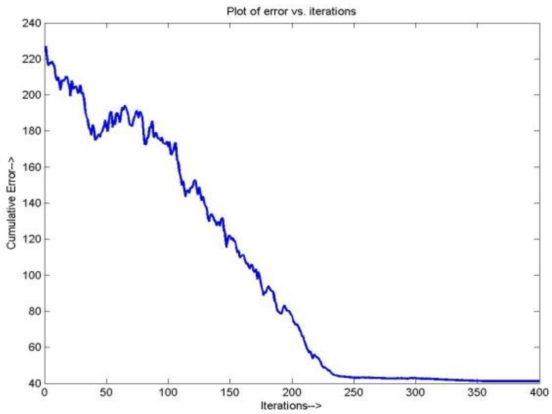

Fig.2: The error vs. Iteration graph

The error values corresponding to Cash Forecasting is shown in Table 3. along with the desired output and the forecasted output for the BP technique. These error values are calculated as

Error Value = (Desired Output – Actual Output)

Table 3: Cash Forecasting using Backprogation

Day No.	Desired Output(in Lacks)	Forecasted Output (in Lacks)	Error Value
1	6.00	8.70	-2.70
2	2.50	8.52	-6.02
3	5.50	8.42	-2.92

The above values are represented graphically in fig. 3.

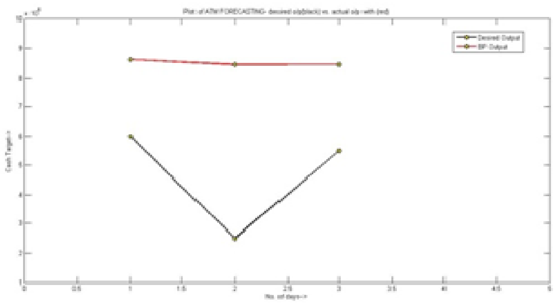

Fig.3: Cash Forecasting for BP technique (red) vs. Desired Output (black)

The comparison of proposed integrated BP/GA technique with the traditional gradient descent based back propagation algorithm is done for the same day's data.

Table 4: The comparison of the BP/GA and BP with the desired output ATM Cash Forecasting

Day No.	Desired Output(in Lacks)	Output using BP(in Lacks)	Error Value for BP	Output using BP/GA(in Lacks)	Error Value for BP/GA
1	6.00	8.70	-2.70	3.70	2.30
2	2.50	8.52	-6.02	1.25	1.25
3	5.50	8.42	-2.92	4.80	0.70

The above comparison shows clearly that the integrated BP/GA technique is more suitable for ATM forecasting than the traditional gradient based back propagation algorithm proposed BP/GA technique is more close to the desired output than the back propagation algorithm. The above values are represented graphically in fig. 4.

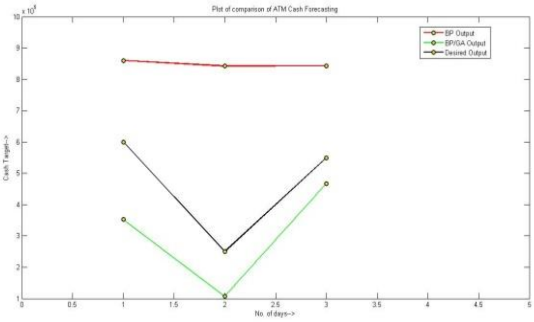

Fig.4: The comparison of the BP/GA technique (green) and BP (red) with the desired output (black) for ATM Cash Forecasting

VIII. CONCLUSION

Since hybrid BP/GA approach offers the benefits of both deterministic gradient based back propagation and random genetic algorithms, the technique is suitable for real time and accuracy demanding ATM forecasting systems. The proposed technique is good at global search and works well for performance oriented ATM forecasting problems. The present research is limited to short term cash forecasting (three-day ahead forecasting). Also the network is trained for one month data.

Due to time and resource constraints, this research was limited to short term predictions only. However, it is the authors' belief that higher accuracy rates could be achieved. Firstly, the predictions could be done based on the calendar division i.e. dividing the model based on holidays, weekends, end of month, festival days etc. Secondly, larger training sets of previous years could be used to improve the performance of the system. Thirdly,more conditions like location of ATM, number of surrounding ATMs, surrounding people's standard of living could be included for more accuracy.

IX. REFERENCES

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