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Using fuzzy logic (type II) in the intelligent ATMs' cash management

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ABSTRACT: The mass of the issues facing today's ATMs, cash management optimization can help banks to manage the system dynamically. The main question in this optimization is, forecasting demand for cash from the ATM, at specified time intervals (e.g., daily or weekly or monthly). Since the structure of the signal (the predicted demand for cash) is nonlinear with many factors, including: days, weeks, days, months, holidays, and even the location of the ATM is connected, the common methods of identification is usually not a good answer and should be used soft computing techniques such as fuzzy logic and neural networks. In this study, the trend methods used in this field explores the application of fuzzy logic (type II) in this issue has been dealt with.
Keywords: ATM, cash management, artificial neural networks, fuzzy logic (Type II), soft computing.

INTRODUCTION

Today, ATMs are one of the most immediate banking system hardware. Optimal management of cash and the availability of ATM network is one of the most important factors in business services. Use efficient and effective cash management can help banks to dynamically system management (Darwish, 2013). Recently most banks are changing their eyes towards obtaining higher performance in the cash management in ATM (Simutis R., Dilijonas, Bastina, Friman, & Drobinov, 2007). The question is to determine the optimum amount of cash that each branch in the specified time periods (e.g., daily) should leave the ATM. Note that ATM may charge extra deposit pocket money to meet the interest of the bank and the deposit is better to be zero. Therefore, the amount of such charge shall be determined by the minimum subsequent investment money we have left. Since the structure of the signal (demand to withdraw money from an ATM) is nonlinear and depend on many factors, such as day of week, day of month, holidays, and even on a busy street or recreational facility where the ATM is located at the weekend, usually conventional identification methods haven't a good response and should be used soft computing techniques such as fuzzy logic and neural networks. Here's an overview of solutions and methods that have been proposed to solve this problem, it is. Since most of the proposed methods use neural networks and fuzzy logic, they will be listed, in the next section.

Artificial neural networks and fuzzy logic

Neural networks are computational systems and techniques which simulation platform aimed at remembering information and learning functions of the human brain. In this networks if a cell is damaged, other cells can compensate for its absence and also be involved in its reconstruction. These networks are capable of learning. An adaptive learning system is done by using the examples, by the new inputs, synapse weights are changed so that the system will produce the right answer. If we consider a graph with an equivalent network, network training process is to determine the weight of each edge and the biases. The artificial neuron can be defined, in this case the number of input and output of each neuron has a bias, and each entry has a weight. Although artificial neural networks aren't comparable with natural nervous system but their features preferred them where there are needs to learn a linear or nonlinear mapping, like as: the ability to learn, the scattering data, the generalization capability, parallel processing and robustness. In short, fuzzy logic can be said that although the words and concepts such as hot, cold, tall, short, young, old, etc. do not point to specific and detailed, but everyone understands surprising flexibility of mind and use them in decisions and conclusions. Variable in nature or in the calculation are two kinds: quantitative values that can be expressed with a certain number and qualitative values that be expressed based on

one characteristic. These two values are convertible. For example, in the case of height of people, if we measure them with a numeric value (cm) and divide them into two category, short and tall, and the classification threshold is 180 cm for tall, in the case of all persons lower than 180 cm are Pygmy based on old logic, even if one's height is 179 cm. But each of these traits based on fuzzy set membership function is defined between zero and one, a membership degree μA(x) represents the degree of membership the element x to the fuzzy set A. The type II is a generalized type I fuzzy. The main difference between the two is that the second type of fuzzy logic, itself is fuzzy, and a new dimension to the footprint of uncertainty (FOU), which is characteristic of this kind of fuzzy systems. It covers more uncertainty. FOU is membership function of the type II in anywhere from two-dimensional domain. (In Figure 1 an example of a fuzzy membership function for comparing the first and second kind.)

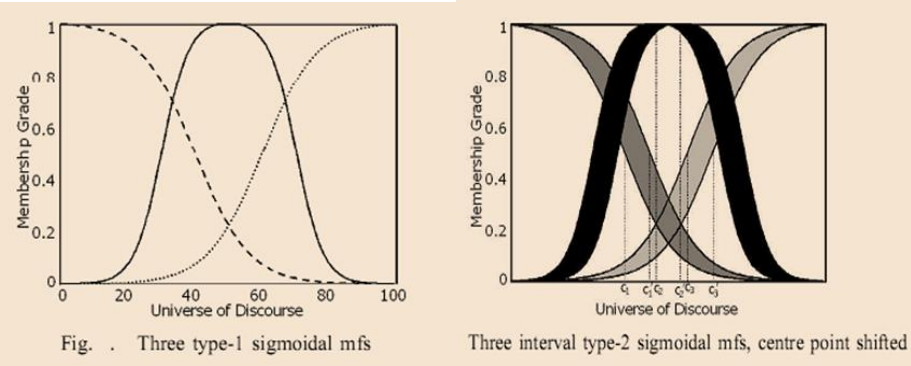

Fig. . Three type-1 sigmoidal mfs

Three interval type-2 sigmoidal mfs, centre point shifted

Figure 1. Sigmoid fuzzy membership functions of type I and type II

METHODS BASED ON NEURAL NETWORKS

The main methods used in the investigation, based on neural networks. Included in the paper, "cash forecasting: an application of artificial neural networks in finance» (Kumar & Walia, 2006) is the capabilities of neural networks to solve this problem. The main idea behind the use of neural networks to forecast cash flows, is the mapping relationships between the various factors influencing entry (cash on ATM) and output (cash needed by the customer). In this study, the minimum percentage forecast error is about 88-92% and the average is 95-96%.
Another important study entitled "optimization of cash management for ATM network" in 2007 (Simutis R. et. all, 2007) based on neural networks and optimization algorithms is presented. Simulation studies show in the case of high cash costs and low investment costs money, optimization procedures can reduce maintenance costs up to 15-20%. Banks typically up to 40% more than the required amount of ATM, the cash they hold. However, many experts consider sufficient excess of 15-20%. 35-60% of total cash costs include the costs of the ATM (Simutis R. et. all, 2007). (It is explained that in our country due to higher interest rates than the countries studied in this paper, cash costs can be even much more than this.) The simulation results show that using neural network solution can request daily average forecast error cash kept below 10%. This approach reduces the cost of day care about 18% (Simutis R. et. all, 2007). Another important study in this regard "cash demand forecasting for ATM using neural networks and support vector regression algorithms," in 2008 (Simutis, Dilijonas, & Bastina, 2008), again based on neural network was presented in two different methods in which neural networks and support vector regression algorithm for daily forecasting ATM cash demand are compared. In this paper it is shown that the neural network methods for the specific application (cash forecasting) has more advantages (Simutis, Dilijonas, & Bastina, 2008). Slightly weaker than forecasting the simulation results are in for a real ATM. MAPE (mean average proportional error) between 15-28% for the neural network and support vector is 17-40% (Simutis, Dilijonas, & Bastina, 2008).
It should be mentioned that in the year 2012 (Armenise, Birtolo, Sangianantoni, & Troiano, 2012) a method for optimizing the ATM cash, using the concepts of genetic algorithms in order to provide the optimal solution can minimize the amount of money that is invested daily cash accumulation, was presented.

Method based on fuzzy logic

An article 2013 (Darwish, 2013) based on the use of fuzzy logic to solve the problem presented. In order to improve the accuracy of prediction, this paper used artificial neural network – interval fuzzy type II.
By optimizing cash management and effective lying money, banks can prevent deposit money and manage the system in a state of dynamic changes, according to the different needs of ATMs.

Optimal cash management starts with an automated solution that uses sophisticated algorithms to predict accurately withdraw money, and gives to the banks the opportunity to effectively forecasting and manage demand. The algorithm must also be flexible enough to allow banks forecasting future environmental changes may re-apply.
The key of forecasting algorithms ATM is receipt and analysis of data records. Recently, some authors have tried to optimize liquidity demand modeling and forecasting (Dilijonas & Bastina, 2007), (Wagner, 2010) and (Brentnalla, Crowderb, & Handb, 2010). However, non-static dispersion and high cash demand processes can affect the ability of each approach.
This research uses the study of a forecasting method based on the rule versus cash management based on time series. Time series method has, fewer calculations, higher speed and greater range of applications, but the prediction accuracy cannot be guaranteed to meet cash needs, and does not have the adaptive learning capability. Proposed method combines, the advantages of neural network - the methods to solve nonlinear problems that cannot be solved with conventional methods - the type II fuzzy controllers - a powerful model for achieving high levels of uncertainty in the real world have been shown - (Darwish, 2013).
In general, cash demand is a stochastic process over time, depending on various factors and high uncertainties, there is a tendency to change. Although neural networks approach for forecasting the cash ATM is already in use, but the method of artificial neural network – fuzzy inference system, used in this study is new. This method not only increases overall system performance forecasting, but also adapt itself for ATM cash demand dynamic nature.
The main idea behind using IT2FNN, allowing the network to map the relationships between the various factors affecting the demand for cash and demand for real cash. A method of creating IT2FNN, is fuzzification a conventional fuzzy neural network. As stated earlier, the type II fuzzy logic specify by fuzzy – fuzzy IF-THEN rules, but the membership functions are three-dimensional and include footprint of uncertainty (FOU). FOU takes an additional degree of freedom to systems that directly support the possibility of modeling the uncertainty associated with the inputs and outputs of the real system. Type II fuzzy rules are more complex than the type I, therefore, most researches of T2FNN focus only on the interval-type II fuzzy systems. Figure 2 shows the generic structure of the network.

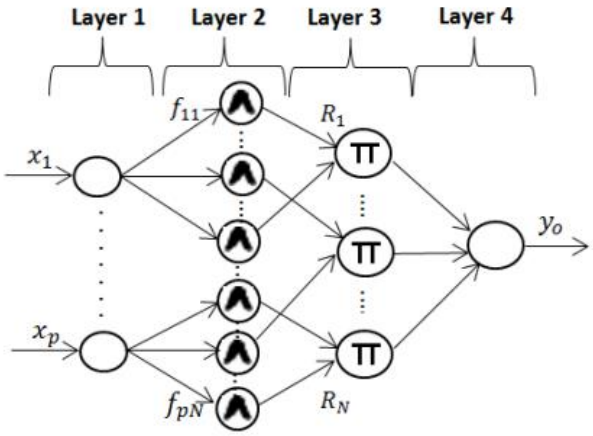

Figure 2. Generic structure of network

Layer 1: factors affecting cash demand include:
Calendar effects (working day, day of week, holidays, waging day and festival days)
The current availability of cash
Average daily cash in last week
ATM locations (lobby, shopping center, tourist spot and within the bank)
are in this layer as input.
Layer 2: is the fuzzification layer. The output of this layer operates as a interval type II fuzzy logic membership function.
Layer 3: Every node in this layer belongs to a rule in set of rules.
Layer 4: The nodes in this layer, calculate the output linguistic variable by type reduction and defuzzification.
To test the potential of ATM cash demand forecasting accuracy of the proposed method, a simulation environment, including 25 ATM, has been designed in MATLAB. The results in Figure 3 is obtained. As you can see, the smart cash management using neural networks - Fuzzy will be reduced the deposit cash rate. The overall average

prediction accuracy of the proposed method (in weeks) is about 72/97% and the minimum accuracy of the predicted is 15/94%.

Conclusion

As mentioned, the smart cash management solution which can be expressed as predictors of cash demand, by soft computing techniques are possible. All papers presented were also the fact, and the vast majority of them have used neural networks to solve the problem. The primary focus in the literature on neural networks and their recent articles, including articles in major (Darwish, 2013), which was published in 2013, including the optimization of their methods and apply these powerful methods such as fuzzy logic (fuzzy logic, especially the kind that cover individual features of uncertainty and noise data), has been moved. In early papers neural network was focused more than recent articles, including articles in major (Darwish, 2013), which was published in 2013, and has been moved toward optimizing of this method to apply the powerful techniques such as fuzzy logic (the second type of fuzzy logic, especially the uncertainty of individual features on the cover of noise data).

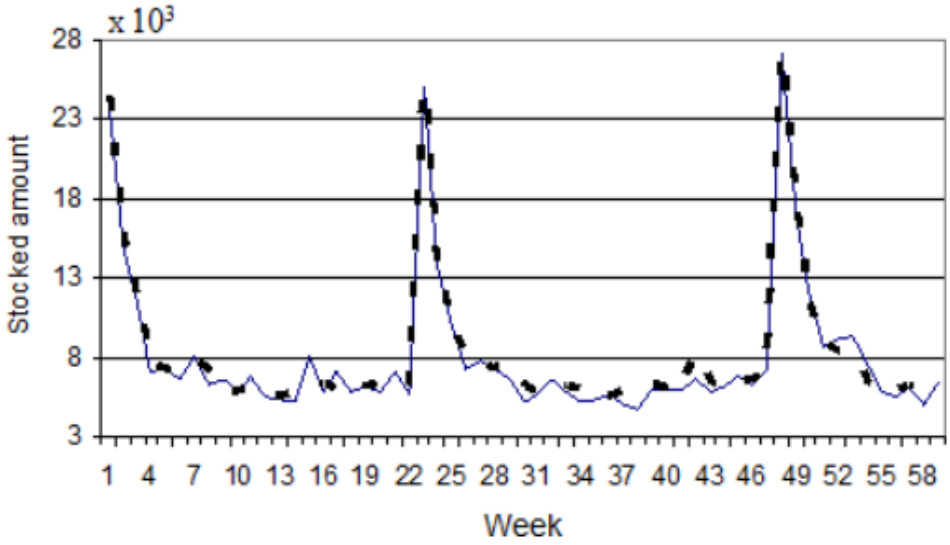

Figure 3. Results of analyzed prediction data: actual values (solid lines) and predicted values (broken lines)

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