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Online Guidance for Effective Investment Using Type 2 Fuzzy-Neuro Advisory System

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***Abstract*— In developing countries major challenge for investor is where to invest savings and hard earn income. This paper presents development of an investment advisory system for Indian investor with the help of neural networks and fuzzy logic. The paper discusses about the techniques used to generate advisory systems. Among various techniques, a type 2 fuzzy logic based interface is selected to achieve human like interface and ease of working with system. Along with the type 2 fuzzy logic, an artificial neural network is employed to achieve self learning for better decision according to market trends. As a result, a hybrid framework of artificial neural network with type 2 fuzzy system is proposed in this system. This base framework of the system can be used to generate different kinds of advisory system and expert systems. To experiment the proposed framework, an Indian environment is chosen and the system and test results are discussed here.**

***Keywords*— Artificial Neural Network, Type 2 Fuzzy System, Neuro-Fuzzy System, Investment, Advisory System.**

I. INTRODUCTION

This paper presents development of Neuro-Fuzzy Advisory System on investment for Indian market. Paper represent concept of hybridization of neural network and fuzzy logic [2]. The fuzzy logic is extended to type 2 fuzzy logic which helps in better representation of vagueness on human mind. Development approach for the advisory system is explained in detail to show how vague fuzzy inputs from users are converted into crisp for machine processing and the output is again converted back in human understandable manner with proper reasoning and suitable advice. An excerpt of the developed system is shown which explains how input and output will be processed.

A. Type 1 Fuzzy System

Fuzzy logic is a multi valued logic derived from crisp logic. Unlike crisp logic which gives answer with a fixed value like 0 or 1 true or false, Fuzzy logic provides answer within a specified range, i.e. answer between 0 and 1, value between true and false, represent the degree of truthiness or falseness in a given statement. It will address the word "approximate" rather than to be "precise". In real world situation we often face problem with vague information. This vague information's are easily understandable by human beings but are hard to interpret computationally. For example weather forecasting, decision making with uncertain conditions, diagnosing problem, speech recognition, image processing etc. To address these types of problems fuzzy systems were introduced often called as Type 1 Fuzzy Systems.

Type 1 fuzzy systems are based on type 1 fuzzy sets. The fuzzy set is defined as "*If X is a collection of objects denoted generically by x, then a fuzzy set A in X is defined as set of ordered pairs: A = {(x, μA(x)) | x X}, where μA(x) is called membership function for fuzzy set A that takes values in the interval [0; 1]*" [2]. It contains four components -- rule base, fuzzification, inference engine and defuzzification, as shown in Fig. 1.

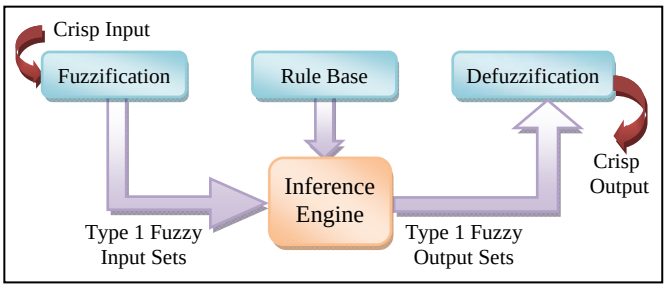

Fig. 1 Type 1 fuzzy system process flow diagram

Fuzzification is the process of conversion of crisp data into fuzzy data. Rule base is a collection of condition with IF-THEN statements. The IF-part of the rule is known as antecedent, and the THEN-part of the rule is known as consequent [13], [14]. Inference engine is used to deduce answer to the problem domain using rule base. Defuzzification will convert deduced fuzzy data back to crisp data for further processing.

B. Type 2 Fuzzy System

Type 1 fuzzy logic is a generalized form of crisp logic. Hence it becomes a difficult task to represent the uncertainty. There are many problem domain and systems which involve high amount of uncertainty in their functions. In most of the real world situations accuracy (near to precise) is important even with uncertain antecedents and/or consequents. This is a limitation of type 1 fuzzy logic as the defuzzified value (a crisp number) captures limited amount of the (rule's) uncertainty.

To overcome this problem type 2 fuzzy systems were introduced [7]. Type 2 fuzzy systems are based on type 2 fuzzy logic which captures more information about the rules uncertainties as shown by [3], [5]. However type 2 fuzzy logic is very complex to interpret computationally. Hence we use

interval type approach in order to reduce the complexity [12], [15]. Type 2 fuzzy system has fuzzy antecedent and or consequent, hence we require a defuzzifier if the value is to be interpreted in a crisp form [8]. The value obtained by type 2 fuzzy system will represent uncertainty far better than type 1 fuzzy system [6].

Type 2 fuzzy systems are closer to human understanding as the representation and inference of uncertainty in analysing the rules is far better. Type 2 fuzzy system uses type reducer in order to convert uncertain rules to type 1 fuzzy value. This value is defuzzified into a number in a given range of domain which is used for further processing. We can give the structure of type 2 fuzzy system as shown in Fig. 2.

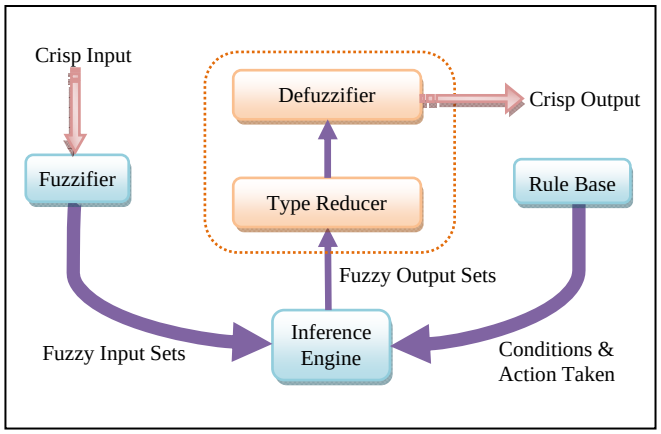

Fig. 2 Type 2 fuzzy system process flow diagram

Like type 1 fuzzy logic systems, type 2 fuzzy logic systems also have their own membership functions which represent fuzzy sets rather than crisp sets. This helps in better understanding of human nature and also provides better logical reasoning. However type 2 fuzzy sets are not necessarily limited to extremely fuzzy situations, they can be used in real world situations also. The example of investment advisory system will represent the real world situation to channelize the thought process of an investor.

II. Methodology

In today's world it's very difficult to make the correct choice in any required specific domain; hence there is need of unbiased advice which is helpful in making the correct decisions. Paper will discuss the investment related problem for an investor in Indian market. The proposed system will provide advice in selecting the proper investment plan for investor, which will assist the investor in choosing for the investment options from various kinds of different investment plans available in the market. The investor has to provide details like what is the amount of investment, what percent of risk investor would like to take, what is the period of investment, etc. in a combined crisp & fuzzy style (which means the human reasoning methods). After collecting the necessary details the system would process the information at various different parts by applying rule bases and inferences. The system uses machine processing for choosing certain types of broad categories and then reach to conclusion of selecting the appropriate investment plan. The output of the system will also be in human understandable format. While investing there is always certain risk involved and the investor's mind will interpret profit, loss and risk in its own manner. Hence to interpret investor logical thinking the system uses type 2 fuzzy logic as it can represent uncertainty (doubts in human mind) almost precisely.

Age, Net Savings, Net Monthly Income, Investment Amount, Investment Risk, Loans & Debts etc, are considered as input parameters to the system. Each of the input is in correspondence with fuzzy value. Here we can see that the system inputs are relative to each other, for example if loans and debts are high in comparison with (relative to) net savings and monthly income then the chances of investment are less or very less investment should be made at very low risk.

Similarly while making a high amount of investment, the investment risk should be considered as an important factor. Hence the decision making part of the system will be a complicated. To reduce the complexity system will use neural network combined with fuzzy inference for such relative factors as the investment differs from person to person. Fig. 3 demonstrates schematic structure of the proposed system.

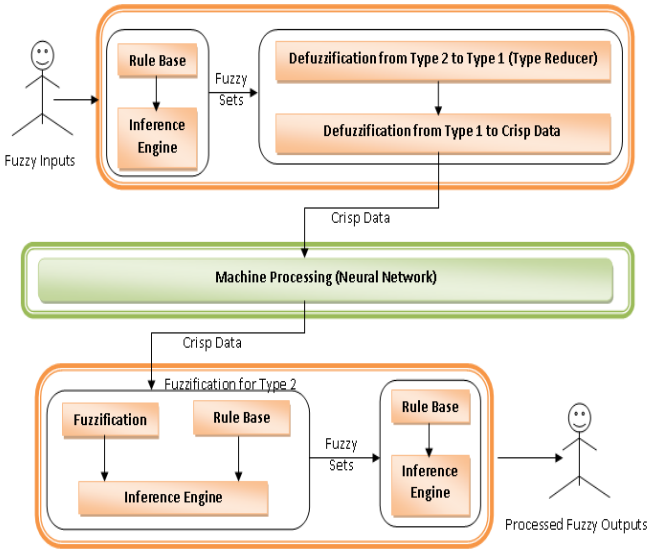

Fig. 3 Type 2 fuzzy-neuro hybridization process for advisory system

A. Fuzzy Input

Input from the investor contains both fuzzy and crisp data. For e.g. Monthly Salary will get crisp data while Investment Risk will get fuzzy data. The Investment Amount and Total Savings will also play major factor in determining the risk of the investment. To handle such kind of relative data we create a rule base and then channelize the input, which is fuzzy or crisp into type 2 fuzzy data. The data is differentiated into different sub part so the understanding of each part is nearly perfect. Hence each linguistic variable will be able to represent information in more precise way [7]. For e.g. Table 1 represents the Investment Risk with its fuzzy value and linguistic variable.

TABLE I
LINGUISTIC VARIABLES FOR INVESTMENT RISK

Linguistic Variable	Associated Fuzzy Number
Definite Safe	F0 = (0.0,0.0,0.0)
Safe:	F1 = (0.0,0.0,0.1)
Nearly Safe	F2 = (0.0,0.1,0.2)
Probably Safe	F3 = (0.1,0.2,0.3)
Unsure	F4 = (0.2,0.3,0.4)
Very Low Risk	F5 = (0.3,0.4,0.5)
Low Risk	F6 = (0.4,0.5,0.6)
Slightly Risky	F7 = (0.5,0.6,0.7)
Risky	F8 = (0.6,0.7,0.8)
Very Risky	F9 = (0.7,0.8,0.9)
High Risk	F10= (0.8,0.9,1.0)
Extra High Risk	F11 = (0.9,1.0,1.0)
Definite Risk	F12 = (1.0,1.0,1.0)

Similarly all the other inputs are blended into common type 2 fuzzy interface which are used by rule base and inference engine of the system.

B. *Defuzzification*

After proper channelizing of input and creating a proper type 2 fuzzy interface, for machine processing we have to pass the data in neural network. As neural network processes the crisp data we convert our fuzzy interface data into crisp form by applying centre of area method [9].

Defuzzification of type 2 will give type 1 fuzzy set and applying the same method will results in crisp output which will be send for neural network processing.

C. *Learning through Artificial Neural Network*

The neural network used for the system is multilayer feed forward back propagation. The input comes from the applied fuzzy inference on the fuzzy data which is defuzzified to crisp data. The output goes to fuzzy inference which will provide output of the system. Hence we have classified input and output of the neural network into broad categories. The Input broad category will contain processed value for Age, Monthly Income, Investment Amount, Investment Risk, Savings, Existing Investment and Debts. The output broad category will contain Government Schemes, Land Investments, Gold Investments, Share Market, and Business Investments. The activation function used will is sigmoid activation function. For faster training different activation functions can be used as shown by [11]. For the selected output broad categories according to their selection rank will be further fuzzified for generating the system advice. Fig. 4 represents artificial neural network for investment advisory system.

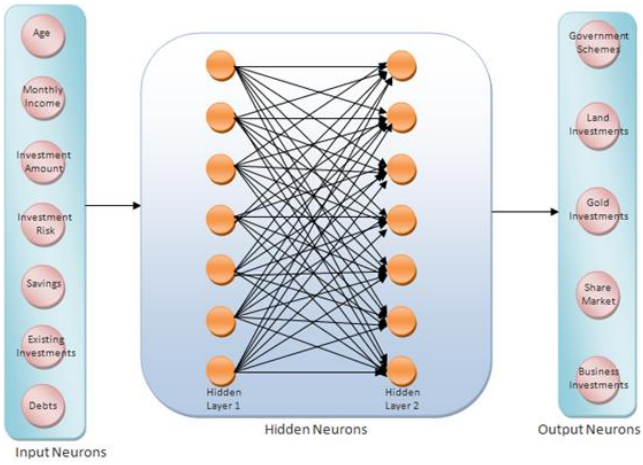

Fig. 4 Artificial Neural Network for Investment Advisory System

D. *Re-Fuzzification*

The re-fuzzification of the selected output broad categories is carried out by applying fuzzy rule base with fuzzy inference engine. The fuzzy data are represented with fuzzy triangular membership functions. These functions are converted to type 2 fuzzy functions using the footprint of uncertainty principle [1]. The end user receives the system advice in type 2 fuzzy interface which are closer to human reasoning logic. The advice generated by the system will be able to satisfy investor's thought process. Fig. 5 represents triangular fuzzy membership function for Investment Risk.

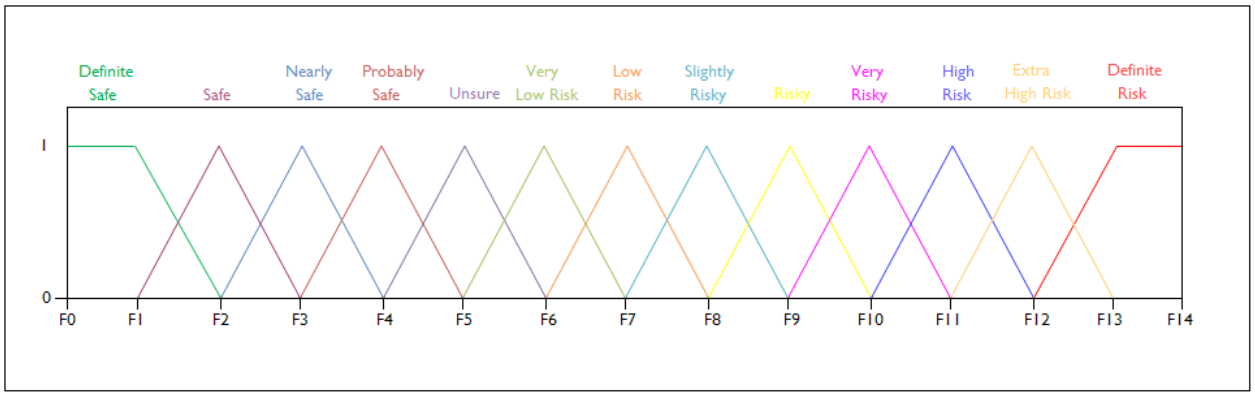

Fig. 5 Triangular Fuzzy Membership Representation of Investment Risk

III. Implementation and Results

By organizing the phases of input, defuzzification, machine learning and refuzzification in an order as shown in Fig. 3, a neuro-fuzzy investment advisory system is generated. The system is trained with member's data from prudent mutual fund (http://www.prudentchannel.com). Following is a sample test case for experiment of the system. Fig. 6 depicts the profile of the system users. Fig. 7 displays advice generated by the system.

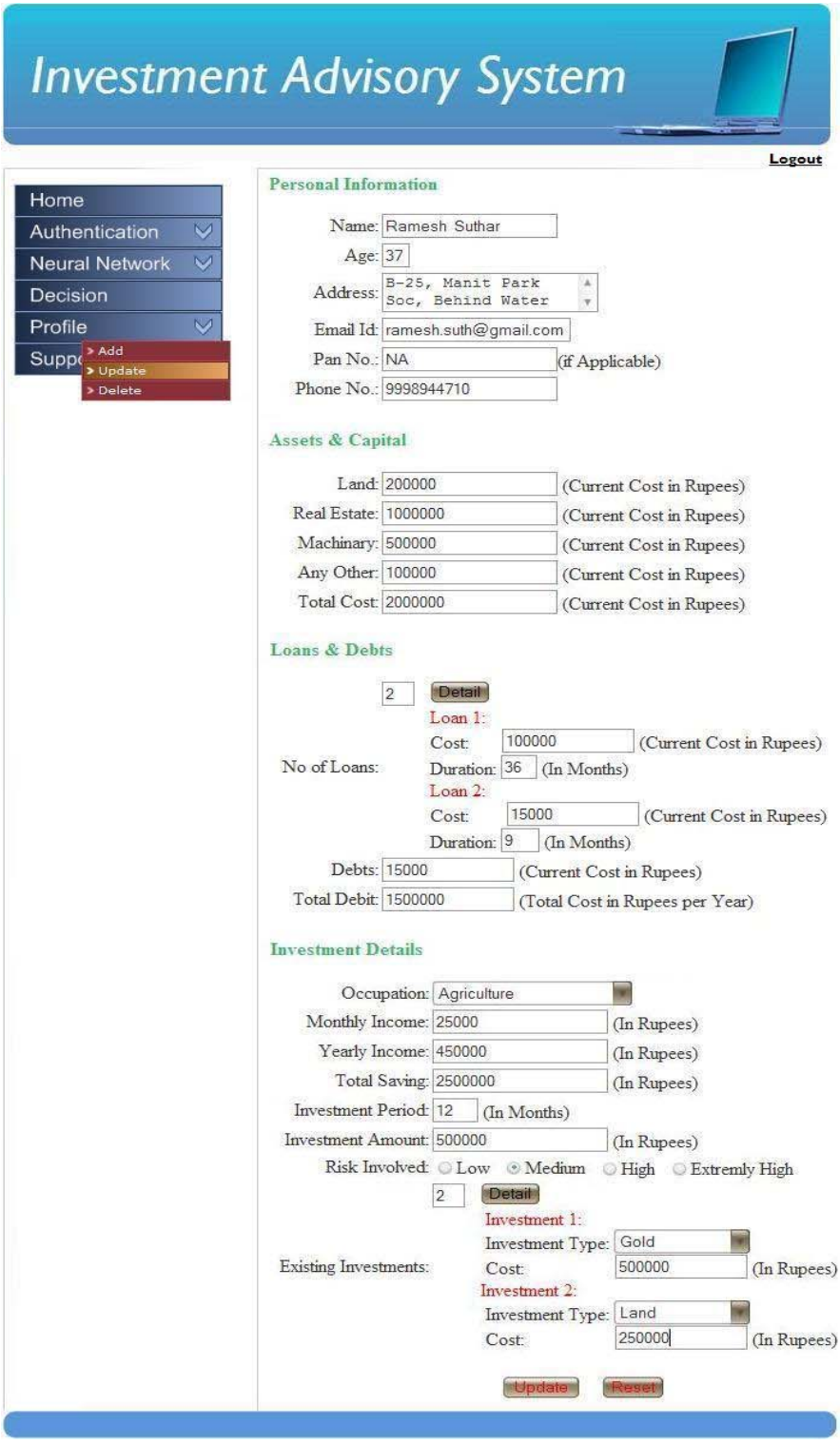

Fig. 6 Profile of an Investor

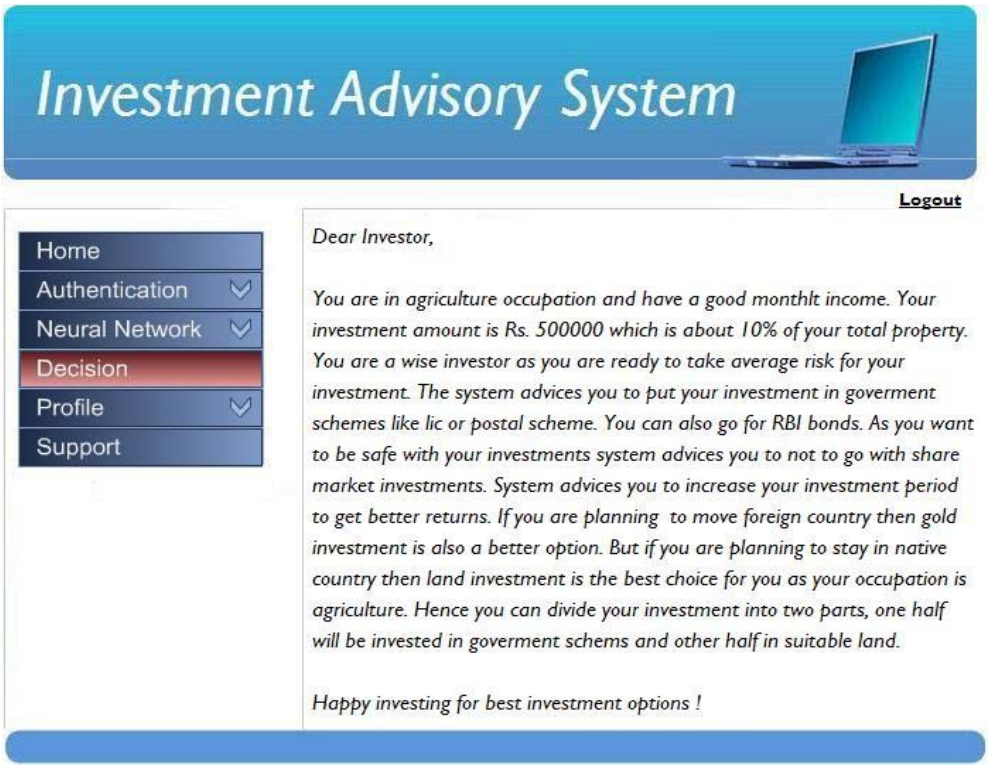

Fig. 7 Advice generated by the system

IV. Conclusions

In this paper we proposed an investment advisory system based on neuro-fuzzy decision support. The fuzzy approach is extended to type 2 to have more realistic and closer to human understanding. The hybridization of machine processing and experts knowledge in fuzzy rule bases will make system work like an expert advisor to the investor. The system was created for the use of Indian investor which is proved to be successful. One can create more of these type of system based on neuro-fuzzy approach which will be useful to different respective fields. Also techniques of fuzzification and defuzzification can be altered to achieve different objectives.

With some minor changes the system architecture can be applied to create different advisory systems in the field of academics, medical analysis, engineering applications, Chemical Industries, Routing Techniques, Course Selections as shown by [4], [10], etc.

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