HYBRID ARTIFICIAL NEURAL NETWORK: COMBINING ARTIFICIAL INTELLIGENCE AND FUZZY LOGIC

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***Abstract*— Artificial Neural Networks (ANNs) are used for solving the problems that have large number of observed cases. Instead of acquiring instances as prior information, fuzzy systems demand language rules. In addition, language descriptions of the input and output variables are required. There are several similarities between artificial neural network and fuzzy systems. They can be utilized to solve an issue if there is no mathematical model for the problem at hand. They have some drawbacks, which are virtually eliminated when both concepts are combined. In this research paper we will be discussing on the proposal of creating Hybrid Artificial Neural Network (HANN) by combining ANN and Fuzzy Logic (FL). In this research paper we will discuss on the problem that we are going to handle and on the solution that we are going to propose to handle the problem.**

Keywords—artificial neural network, artificial intelligence, fuzzy logic.

I. INTRODUCTION

Artificial Neural Networks can only be used if the problem has a large number of observed cases. The black box is trained using these observations. On the one hand, no prior understanding of the issue is required. On the other hand, extracting intelligible rules from the structure of a neural network is not simple.

Instead of acquiring instances as prior information, fuzzy systems demand language rules. In addition, language descriptions of the input and output variables are required. The fuzzy system must be tweaked if the knowledge is inadequate, incorrect, or contradicting. Because there is no formal method for doing so, the tuning is done haphazardly. This process is usually very time consuming and error prone.

There are several similarities between artificial neural network and fuzzy systems. They can be utilized to solve an issue if there is no mathematical model for the problem at hand. They have some drawbacks, which are virtually eliminated when both concepts are combined.

A Hybrid Neural Network is homogeneous and usually resembles neural networks. The fuzzy system is understood as a special type of neural network in this case. The architecture of such a hybrid neural fuzzy network system has the advantage that neither the fuzzy system nor the neural network must communicate with each other. They have merged into a single entity. These systems have the ability to learn both online and offline.

A neural network is used to interpret the rule basis of a fuzzy system. The input and output variables, as well as the rules, are described as neurons, and fuzzy sets can be thought of as weights. In the learning process, neurons can be added or removed. Finally, the fuzzy knowledge base is represented by the network's neurons.

Membership functions that express the language words of the inference rules must be developed before a fuzzy controller can be built. There is no formal technique to defining these functions in fuzzy set theory. With an arbitrary set of parameters, any shape can be considered a membership function. As a result, for fuzzy systems, optimizing these functions in terms of data generalization is critical. This problem can be solved using neural networks.

A typical Hybrid Neural Network by combining Arificial Intelligence and Fuzzy Logic has a number of interesting characteristics[1][2][3].

Firstly, a data-driven learning strategy derived from neural network theory is used to train a hybrid neural network based on an underlying fuzzy system. Only local information is used in this heuristic to generate local modifications in the fundamental fuzzy system.

Secondly, a hybrid neural network can be modeled as a collection of fuzzy rules at any point during the learning process, including before, during, and after. As a result, the system can be set up with or without prior understanding of fuzzy rules.

Thirdly, to assure the semantic features of the underlying fuzzy system, the learning procedure is constrained.

Fourthly, a hybrid neural network approximates an n-dimensional unknown function represented in part by training samples. As a result, fuzzy rules can be interpreted as vague prototypes of the training data.

Fifthly, a hybrid neural network is a three-layer feedforward neural network consisting of the following layers [3]: I) The first layer corresponding to the input variables. II) The second layer symbolizing the fuzzy rules. III) The third layer representing the output variables. IV) The fuzzy sets are converted as fuzzy connection weights. V) Some approaches use five layers with the fuzzy sets encoded in the second and fourth layer units, respectively. However, these models can be transformed into a three-layer architecture.

II. SOLUTION IDEA

Hybrid Neuro-Fuzzy Network Systems are highly suited for the development of interactive data analysis tools that allow for the creation of rule-based knowledge from data as well as the inclusion of a-priori knowledge into the data analysis process [4]. The fundamental idea behind a hybrid neuro-fuzzy network system is to combine the benefits of fuzzy systems with neural network learning capabilities. It is thus possible to interpret the network topology and apply prior knowledge to the learning process in a straightforward manner utilizing fuzzy rules.

Despite the extensive study in the field of hybrid neuro-fuzzy network systems, recurrent forms of this design have received very little attention [4]. Recurrent models, in contrast to pure feed forward designs, which have a static input output behavior, can store knowledge about previous system states and are hence more suited to the analysis of dynamic systems [5]. If pure feed forward architectures are used to solve these difficulties, the resulting system data must usually be preprocessed or restructured in order to properly map the dynamic information.

This fundamental concept of the hybrid neuro-fuzzy network system is to mix simple feed forward fuzzy systems with arbitrary hierarchical models. As a result, before, during, and after optimization, each part's interpretability is ensured. Time delayed feedback linkages are used to create backward connections between the models. The usage of connected weights in the consequents (fuzzy sets allocated to the same linguistic concepts share their parameters) and antecedents ensures the interpretability of the fuzzy sets (layer two). Furthermore, limitations can be defined that the learning technique must adhere to.

The learning approach of the hybrid neuro-fuzzy network system is consisted of the following two learning phases [4]: I) Rule Base Learning. II) Rule Base Optimization.

The fundamental premise of the rule base learning method is to learn a hierarchically structured rule base of local subsystems. This facilitates the inclusion of past information and the whole rule base's interpretability. The approach enables the use of rule templates to train subsystems, which are systems that use only a subset of input and output variables and possibly extra inner variables. These templates are intended to specify the variables and associated time delays that should be used while building a certain subsystem. As a result, each subsystem can be optimized independently of the others while ensuring that each subsystem, and hence the entire rule base, remains interpretable. For each investigated domain, the algorithm requires an existing fuzzy partitioning.

The Real Time Recurrent Learning Method (RTRL) for recurrent neural networks inspired the suggested method for rule base optimization [6]. The goal is to feed back the error from the output units through the hierarchical fuzzy system's rules and adjust the fuzzy sets accordingly [6]. If feedback connections must be taken into account, the fuzzy rule base is unfurled in time and the error propagated backwards in time.

It's worth noting that recurrent hybrid neuro-fuzzy network systems are more sensitive to tiny changes in the variables because the system's error-prone output is also used as feedback input, and therefore the error may reinforce itself. As a result, obtaining a good approximation performance is frequently more critical than ensuring good interpretability, which is normally the goal in the design of feed forward neuro-fuzzy approaches. To acquire a viable solution, the learning restrictions, which are utilized in feed forward architectures to assure a good interpretability of the learnt fuzzy rule base, must frequently be reduced or even ignored.

Hsu has proposed self-organizing adaptive fuzzy neural network for nonlinear systems [6]. The identifier is used to estimate the controlled system’s dynamic with the learning of system. The parameter learning algorithms are derived using the Lyapunov function [6].

The training methods for neural networks of the hybrid neuro-fuzzy network system can be divided into following two large types [7]: I) Gradient-Based Algorithms. II) Evolutionary Algorithms.

To decrease error function and define fuzzy connection weights and biases, the evolutionary algorithms based strategy to training the hybrid neuro-fuzzy network system uses genetic algorithms and other population based natural evolution inspired algorithms [8]. Because evolutionary algorithms do not rely on derivative knowledge, they are most effective when the derivative is difficult to obtain, if not impossible.

Despite the extensive study in the field of hybrid neuro-fuzzy network systems, recurrent forms of this design have received very little attention [5][9]. Recurrent models, in contrast to pure feed forward designs, which have a static input output behavior, can store knowledge about previous system states and are hence more suited to the analysis of dynamic systems [6]. If pure feed forward architectures are used to solve these difficulties, the resulting system data must usually be preprocessed or restructured in order to properly map the dynamic information [4].

In our future research we will be working on the design of the hybrid neuro-fuzzy network system using genetic learning algorithm to solve the problem of dynamic system control. We will be designing recurrent hybrid neuro-fuzzy network systems processing directly fuzzy information and using fuzzy weights and biases as adjustable parameters.

In our future research we will be working on the design of the hybrid neuro-fuzzy network system with the following salient charactertics: I) Efficient Rule Based Learning of Fuzzy Logic of Hybrid Neuro-Fuzzy Network System. II) Efficient Training of Neural Network of Hybrid Neuro-Fuzzy Network System.

III. CONCLUSION

In this research paper we have discussed on the proposal of creating hybrid artificial neural network by combining artificial neural network and fuzzy logic. There are several similarities between artificial neural network and fuzzy systems. They can be utilized to solve an issue if there is no mathematical model for the problem at hand. They only have a few drawbacks and benefits, which are virtually eliminated when both concepts are combined. In this paper we have discussed on the problem that are going to handle and on the solution that we are going propose to handle the problem.

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