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NEUROFUZZY SYSTEM — FUZZY INFERENCE USING A STRUCTURED NEURAL NETWORK

Ryusuke Masuoka, Nobuo Watanabe, Akira Kawamura,
Yuri Owada, and Kazuo Asakawa
FUJITSU LABORATORIES LTD., 1015 Kamikodanaka,
Nakahara-ku, Kawasaki 211, Japan

1 Introduction

We propose a neurofuzzy system that enables conversion between fuzzy systems and neural networks while augmenting the advantages of both.

Systems fit to express fuzziness are relatively easy to understad, but not so neural networks. Neural networks can learn, however, but not so fuzzy systems, which must be tuned manually — a time-consuming process.

Unlike neurofuzzy systems proposed thus far [1], our system enables us to switch from fuzzy systems to neural networks and vice versa. Such a possibility is of great help in determining how neural networks do their work. Especially for those who use a neural network in place of a fuzzy system for control, it is useful to know what rules neural networks use for control. Study in this area may also lead to actualizing automatic knowledge acquisition. After neural networks are made to learn input-output relation, fuzzy rules to realize these input-output relation can be extracted from those neural networks.

Another advantage of our system is that an entire fuzzy system can be mapped into a neural network, make it possible to apply ordinary neural networks and learning algorithm.

2 System Overview

Fig. 1 shows our neurofuzzy system. Fuzzy rules are extracted from experts and a rough model is constructed without target system. These fuzzy rules in the fuzzy system are used to preweight the neural network, which is then tuned using output from an actual plant or selected learning data. Once the neural network has learned this data, it is ready to use. This produces a usable system faster than using only a fuzzy system or only a neural network. Tuning a fuzzy system manually is time-consuming. Constructing a neural network from scratch often ends up with local minimun.

If the internal representaion of the neural network is needed, the neural network can be remapped into a fuzzy system. Fuzzy rules extracted from the neural network can then be evaluated. Unsuitalbe rules can be corrected and you can restart with this corrected fuzzy system.

3 Fuzzy to Neural

Fuzzy system involves control written by membership function [2]. A rule looks like this.

If (A is small) AND (B is large) then (X is medium).

A and B are parts input to the system. AND is a fuzzy operation. X is a operational value for the target system. Small, large, and medium are expressed by membership functions — that on the left being called an LHS membership function, e.g., small or large, and that on the right an RHS membership function, e.g., medium.

The values of A, B and other input are entered into the system, then the fuzzy operation AND of "A is small" and "B is large" is calculated. The result is called the grade for the RHS membership function, and is used to multiply medium. Repeating this produces a function corresponding to each rule. All functions thus obtained are summed and the center of gravity of this summed function is calculated for use as the operational value.

This fuzzy system is then mappped into a neural network (Fig. 2). This neural network consists of the input variable membership net (IVMN), the rule net (RN), and the output variable net (OVMN).

Each LHS membership function is actualized in IVMN. The IVMN outputs the grades of LHS membership functions for the input. A three-layer neural network consisting of 1 input unit, 1 or 2 hidden units, and 1 output unit corresponds to each LHS membership function. Membership functions are approximated by sigmoid functions.

Each fuzzy operation such as AND is expressed by one neuron in the RN. The RN outputs the grades of RHS membership functions. Fuzzy operations are realized in the weights in the RN. Sometimes a neural network with the completely wired RN is used (Fig. 3) While a neural network of Fig. 2 permits only changes to the rules which already exist, this type of neural network enables the possibility of learning new rules

RHS membership functions and calculation of the center of gravity are actualized in the OVMN. The OVMN outputs the center gravity of the sum of RHS membership functions multiplied by grades.

Connections in IVMN, RN and OVMN can be tuned independantly.

4 Neural to Fuzzy

In extracting fuzzy rules from neural networks, the usual approach is to treat the neural network as a black box and to reference what is output for what is input (Hidden units are taken into account in [3]). In contrast, we go inside the neural network. ¿From the start we prepare a neural network suited to fuzzy reduction like one in Fig. 3. Fuzzy reduction is based on the pruning technique of neural network connections and units.

The network is assumed to have learned data. Connections or neurons below a given level in the RN are pruned or removed, and the network is made to relearn data until it assumes the network form in Fig. 2. The neural network can then be easily mapped into a fuzzy system with fuzzy rules.

5 Conclusion

We have proposed a neurofuzzy system that combines fuzzy systems and neural networks. Using this system make it easier to develop and modify a control system than using either a fuzzy system or a neural network. It also provides a way to understand how neural networks work.

References

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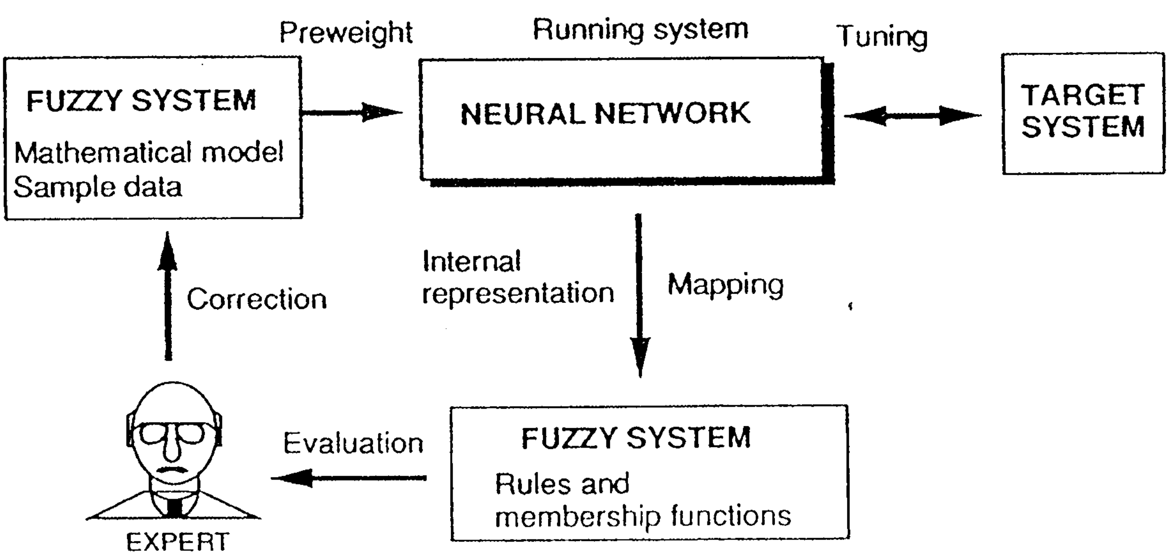

Figure 1. Neurofuzzy system