The Principle of Maximum Entropy-Based Two-Phase Optimization of Fuzzy Controller by Evolutionary Programming

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Abstract. In this paper, a two-phase evolutionary optimization scheme is proposed for obtaining optimal structure of fuzzy control rules and their associated weights, using evolutionary programming (EP) and the principle of maximum entropy (PME) based on the previous research [1].

1 Two-Phase Evolutionary Optimization

A fuzzy logic controller (FLC) with weighted rules, which is equivalent to a conventional fuzzy controller with a weighting factor of each rule, is adopted [2] and a two-phase evolutionary optimization scheme is applied to the FLCs.

In the first phase, initial population for rule structures are given as a stable fuzzy rule. Rule structures and scale factors of the error, change of error and input to the FLC are optimized by EP. The variation of the rule structures is done by the adjacent mutation operator and the scale factors are mutated by the Gaussian random variables. The objective function is constituted by the sum of error, sum of input and the number of used rules.

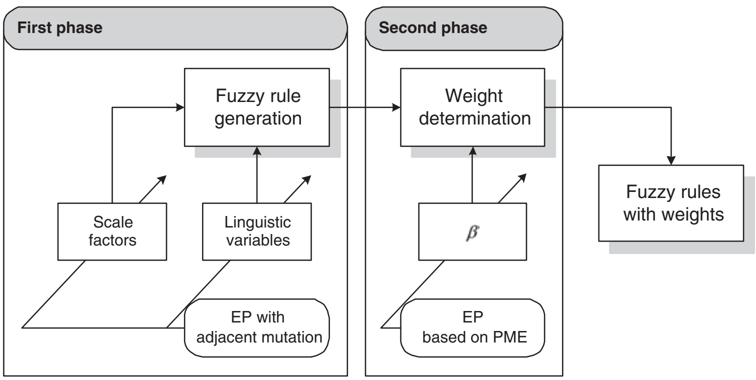

Fig. 1. Overall structure of the two-phase evolutionary optimization

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In the second phase, the resultant rules and scale factors of the first step are used. Then PME is applied to determine the weight of each fuzzy rule efficiently. The application of the PME in finding the weights is based on the assumption that all the rules should be utilized to the greatest extent.

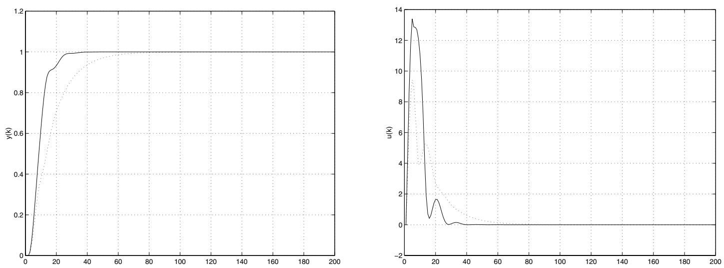
The optimization of the second phase can be regarded as fine tunning for the desired output response of the controlled system. Since only several decades of generation is needed for determining the weights in the second phase, the proposed scheme can be used for the on-line control of the time-varying plant. The effectiveness of the proposed scheme is demonstrated by computer simulations.

2 Simulation Results

Consider the following plant:

$$H(z^{-1}) = \frac{1}{2\pi} \cdot \frac{0.02940z^{-1} + 0.01532z^{-2} + 4.643 \times 10^{-5}z^{-3}}{1 - 1.039z^{-1} + 0.03870z^{-2} - 8.993 \times 10^{-8}z^{-3}} \tag{1}$$

In Figure 2(a), solid line is the step response of the second phase, while dotted line is the response of the first phase. The figure shows that the performance can be considerably improved by employing the second phase. The control input is also compared in Figure 2(b).



(a) Step response of the system

(b) Control input

Fig. 2. Step response and control input using fuzzy rule obtained in the second phase

References

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2. M. Mizumoto, "Fuzzy controls by fuzzy singleton-type reasoning method," Proc. of the Fifth IFSA world congress, Seoul, Korea, pp. 945–948, 1993.