Evolving Fuzzy Rules in a Learning Classifier System

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The fuzzy classifier system (FCS) combines the ideas of fuzzy logic controllers (FLCs) and learning classifier systems (LCSs). It brings together the expressive powers of fuzzy logic as it has been applied in fuzzy controllers to express relations between continuous variables, and the ability of LCSs to evolve co-adapted sets of rules. The goal of the FCS is to develop a rule-based system capable of learning in a reinforcement regime, and that can potentially be used for process control.

Learning classifier systems are rule based machine-learning systems that can evolve rules in a reinforcement learning environment. In a LCS, automatic mechanisms adjust the strengths of rules according to their ability to receive payoff from the environment. A genetic algorithm runs over the population of rules, creating new rules by recombining those that have been successful in the past. The syntax commonly used in LCSs is designed for binary message matching, and therefore has great difficulty when dealing with continuous variables.

Fuzzy logic controllers have shown how fuzzy logic can be successfully applied to express in a few rules mappings between continuous variables. Their success is backed by a long list of applications. Nevertheless, in most of these applications, the designer of the FLC has developed the rules by hand, from interviews with the operator, from knowledge of the process, or from an operator's manual. No automatic way to develop sets of fuzzy rules for a FLC has gained recognition. In a FLC rules sets are stimulus-response, they do not take into account variables not directly supplied to the controller. The control of dynamic systems has usually been achieved by not only giving the reference and the error as inputs to the FLC, but also giving the derivative and integral of the error. Very complex processes might require the controller to take into account higher order derivatives or functions of variables that the designer might not be aware of. The FCS attempts to take advantage of LCSs ability to develop chains of rules automatically, and thus offer to the field of fuzzy control, characteristics not found in common FLCs.

Initial results show that the FCS can effectively create fuzzy rules that imitate the behavior of simple static systems. The current research work is directed towards increasing the learning rate of the FCS while retaining stability of that which has

been learned, and the imitation of more complex static systems. The next steps will be oriented towards the control of simple dynamic systems.