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A fuzzy-based lifetime extension of genetic algorithms

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Abstract

In knowledge discovery, Genetic Algorithms have been used for classification, model selection, and other optimization tasks. However, behavior and performance of genetic algorithms are directly affected by the values of their input parameters, while poor parameter settings usually lead to several problems such as the *premature convergence*. Adaptive techniques have been suggested for adjusting the parameters in the process of running the genetic algorithm. None of these techniques have yet shown a significant overall improvement, since most of them remain domain-specific. In this paper, we attempt to improve the performance of genetic algorithms by providing a new, fuzzy-based extension of the LifeTime feature. We use a Fuzzy Logic Controller (FLC) to adapt the crossover probability as a function of the chromosomes' age. The general principle is that for both young and old individuals the crossover probability is naturally low, while there is a certain age interval, where this probability is high. The concepts of "young", "old", and "middle-aged" are modeled as linguistic variables. This approach should enhance the exploration and exploitation capabilities of the algorithm, while reducing its rate of premature convergence. We have evaluated the proposed Lifetime methodology on several benchmark problems by comparing its performance to the basic genetic algorithm and to several adaptive genetic algorithms. The results of our initial experiments demonstrate a clear advantage of the fuzzy-based Lifetime extension over the "crisp" techniques.

Keywords: Genetic algorithms; Fuzzy logic; Fuzzy genetic algorithms; Adaptive fuzzy control; Optimization; Fuzzy rule-based systems

1. Introduction

In knowledge discovery, *Genetic Algorithms* have been used for classification, model selection, and other optimization tasks. Practically, GA provides a general-purpose search methodology, which uses

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principles of the natural evolution [13,19]. However, behavior and performance of genetic algorithms are directly affected by the interaction between their parameters [7], which have fixed values in the Simple Genetic Algorithm [18]. Poor parameter settings usually lead to several problems such as *premature convergence*.

Adaptive techniques have been suggested to adjust parameters in the process of running the genetic algorithm. These include adapting mutation probability (*P*m), crossover probability (*P*c), both *P*m and *P*c, population size (*N*) [1,8,28], and even the crossover operator [27]. Lately, several features have been added to the basic genetic algorithm in order to emulate the natural evolution process as precisely as possible. Particularly, the approach called GAVaPS - GA with varying population size [2], which utilizes the concept of LifeTime and age, has shown promising results. Further studies enhancing the basic GAVaPS took place in [10,11] combining known features like incest prohibition and mating between individuals with phenotype similarities.

Recently, there has been an increasing interest in the integration of Fuzzy Logic (FL) and Genetic Algorithms (GAs). The motivation is to control GA parameters based on fuzzy logic techniques [14,15,17]. Currently, experience and knowledge on GA have become available as a result of empirical studies, which may be useful for avoiding premature convergence and improving GA behavior. However, too much of this information is vague, incomplete or ill structured which causes it to be rarely applied. Therefore, the use of fuzzy logic would be suitable for dealing with this type of information. The good performance of the FGA (Fuzzy GA) approaches leads to an important conclusion: GAs may be improved through the use of FL.

The purpose of this work is to test the effect of fuzzy-based lifetime extension of genetic algorithms through the adaptation of crossover probability. Like in the nature, crossover is practically a method for sharing information between two chromosomes. In the simple genetic algorithm, this action takes place with a certain probability, called crossover probability. The crossover probability has been found crucial to the genetic algorithm performance [24], and since its value varies a lot across different domains, it would be most contributing to focus on it. Therefore, we enhanced the GAVaPS algorithm with a fuzzy logic controller, which adapts the crossover probability according to a fuzzy rule base. We expect to maintain the genetic diversity of a GA and create conditions for reducing the percentage of runs in which the algorithm gets trapped in local optima.

The paper is organized as follows: Section 2 gives an overview of related work on GA with varying population size and fuzzy logic control. Section 3 describes the proposed Lifetime extension of GA, while Section 4 presents the results of applying the proposed method to three benchmark problems: Royal Road, Traveling Salesman, and OneMax. Section 5 concludes the paper with the summary of results and directions for future research.

2. Previous work

2.1. Genetic algorithms

GA provides a general-purpose search methodology, which uses principles inspired by natural genetics to evolve solutions to problems [13,19]. The simple genetic algorithm starts off with a population of randomly generated chromosomes, each representing a candidate solution to the concrete problem being solved, and advances towards better chromosomes by applying genetic operators, which correspond