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Global minimum routing in evolutionary programming using fuzzy logic

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ABSTRACT

It is well known that one of the basic advantages of evolutionary programming is in deciding the most suitable place for breeding offspring and finding the route toward the global minimum. To reach this goal, the algorithm needs to estimate the coordinates of the global minimum and then steer the new point toward it. In this paper, the estimation of the global minimum is calculated by weighted mean coordination of individuals (WMP), and then a road is mapped between the coordinates of the parents and the WMP. In the proposed method, fuzzy logic is used for deciding on the road and the best coordination to breed offspring. The proposed algorithm is tested on 65 well-known cost functions and is compared with five algorithms inside the EP family. In the next section of the paper, the algorithm is tested on the high-dimensional problem of modeling ozone layer data, which includes almost 26,000 unknown parameters. The results demonstrate the capability of the proposed method in having acceptable speed and accuracy.

1. Introduction

Evolutionary algorithms (EAs) are a subset of evolutionary computation, i.e., generic population-based meta-heuristic optimization algorithms. An EA uses a number of mechanisms inspired by biological evolution, including reproduction, mutation, recombination and selection. Candidate solutions for the optimization problem play the role of individuals in a population, and the fitness/cost function determines the environment within which the solutions "live". Evolution of the population then takes place after the repeated application of the above operators.

In the case of evolutionary computation, there are four historical paradigms, which serve as the basis for most of the activities in the field: Genetic Algorithms (GA) [15], Genetic Programming (GP) [18], Evolutionary Strategies (ES) [29] and Evolutionary Programming (EP) [10]. The basic differences between the paradigms lie in the nature of the representation schemes, reproduction operators and selection methods [33].

The general format of CEP (Classical EP) follows a two-step process of selection and variation in a population. Following the initialization of a population, the fitness of each individual in the population is scored with respect to an arbitrary fitness function. Parents are randomly varied to generate offspring, and the fitness of each member in the population is re-evaluated. Mutation is the only operator in the EP for producing offspring, which is often implemented by adding a random number or a vector from a certain distribution (e.g., a Gaussian distribution in the case of classical EP) to a parent [2]. In

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classical EP, the region of each parent is a location to breed the related offspring, and only one individual takes part in producing new offspring (Fig. 1). In this method, the place and cost of other parents do not affect the decision regarding the coordinate of the offspring. Hence, this approach can also be regarded as a blind search scheme. For a detailed review of EP variants and their adaption, refer to [2,3]. For review on application of EP variants, refer to [5,6,20,32].

In meta-heuristic techniques, there are some information that can be used to prevent blind searching. For example, each parent has information of location and the cost of parents. The cost of parents specifies whether its location is suitable for breeding offspring or not. An evolutionary programming method that uses these information can enhance its performance. For example, consider Fig. 2, in which the two parents decide on the offspring location.

It is obvious that one of the basic advantages of EP is deciding on the most suitable place for breeding offspring and finding a route to the global minimum. Some variants of EAs benefit from the introduced information for better routing. The Stud GA [19] uses the best-found individual (elite individual) in a crossover operator to breed more elite individuals. Similar elitism can be seen in other algorithms, such as Particle Swarm Optimization (PSO). PSO [25] uses the global best point and local best points to steer other individuals toward the optimum region in which the global minimum is likely to be found. Although this information helps the algorithm to search the map mindfully, using this information increases elitism in the algorithm.

To improve the breeding region for offspring, the algorithm needs to estimate the coordinate of the global minimum and then steer the new point toward it. In addition to the problem of estimating the global minimum, producing new points near the estimated point increases elitism in the algorithm, which causes traps in the local minimum and a loss of accuracy. In this paper, the road map to the global minimum and the best region for producing the offspring are evaluated using fuzzy logic. Two factors of speed and accuracy are considered, and an attempt is made to improve the EP algorithm in regard to both factors. The proposed method benefits from the cost and coordinates of parents for deciding on the estimation of the global minimum region; then, the fuzzy logic decides on the route to reach this destination. The proposed method can speed up the algorithm without decreasing its accuracy. Moreover, theoretical aspects of the proposed method are included, and it is compared inside and outside of the EP family. The results show the capability of the proposed method.

In the second part of the paper, the proposed algorithm is tested on the very high dimensional problem of modeling ozone layer data, which includes almost 26,000 unknown parameters.

The organization of this paper is as follows: Section 2 explains and presents the theoretical aspects of FREP (Fuzzy Routing Evolutionary Programming). In Section 3, the proposed method is compared with other EP variants. Section 4 compares the

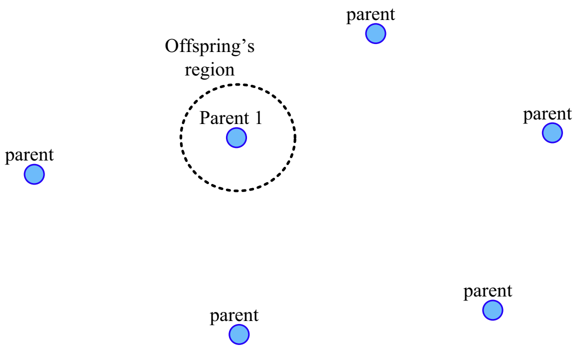

Fig. 1. Offspring production region in classical EP.

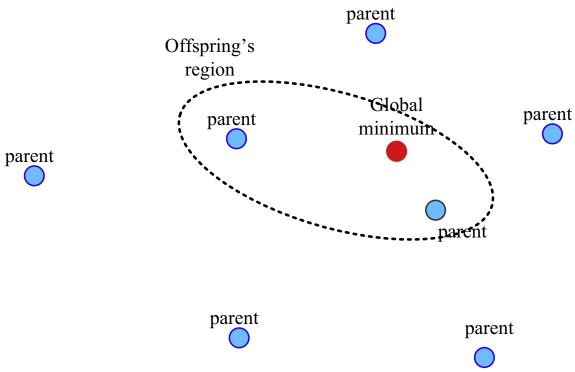

Fig. 2. The region for producing offspring using the coordinates of two parents.