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Development of the Tournament Selection-based Genetic Algorithms with the Aid of a New Selection Method

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Abstract. This paper proposes a method that combines tournament selection-based genetic algorithms (GA) with simulated annealing (SA) to improve the performance of GA. Furthermore random signal-based learning (RSBL) is added as an additional GA operator to refine the solutions after mutation. The fuzzy controller for the inverted pendulum is used to verify the validity of the proposed method.

Keywords: genetic algorithms, simulated annealing, tournament selection

1 Introduction

To search an optimum of a function with continuous variables is difficult if there are many peaks and valleys. In these cases, traditional optimization methods are not competent. They will either be trapped to local optima or need much more search time. In recent years, many researchers have been trying to find new ways to solve these difficult problems, and stochastic approaches have attracted much attention [1-4].

This paper proposes a new method that combines the recombinative power of GA [3] and local selection of SA [5] by using a SA-selection, and random signal-based learning [4] is applied as an additional GA operator to refine the solutions as well. The proposed method is applied to the optimization of the fuzzy controller for the inverted pendulum to show the validity of the proposed algorithm.

2 Proposed Algorithm

In this section, the new selection method called SA-selection is introduced and applied to tournament selection-based GA to get the synergy effect between GA and SA.

Tournament selection takes two competing individuals from the population at random and select single winner as a parent until the number of selected winner reaches population size. The main concept of SA-selection is to choose a single candidate solution between parent, offspring, and best solution of the generations, where offsprings are taken by applying crossover, mutation, and RSBL to parents. RSBL is ap-

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plied to every phenotype of the chromosome and searches new state that is close to the current state (local search).

In this approach, SA-selection is applied to tournament selection-based GA effectively without increasing the number of performance index evaluation per generation because SA allows uphill move to explore the search space in higher temperature and exploit the search space accepting the best solution's individual in lower temperature. The flowchart of the proposed algorithm is described in Fig. 1.

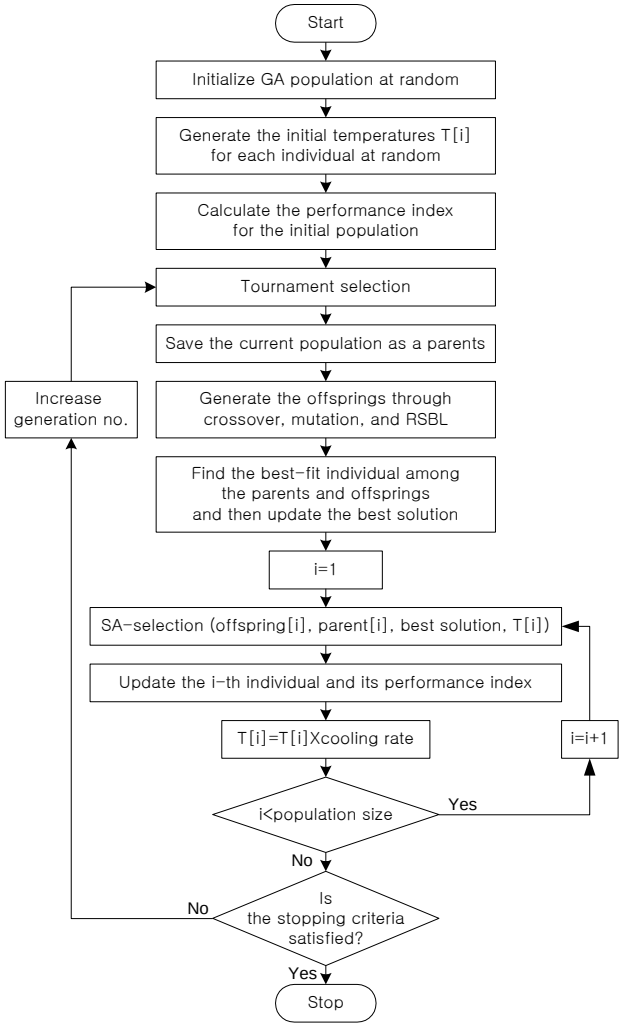

Fig. 1. Flow chart of the proposed algorithm

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3 Experimental Results

To show the effectiveness of the proposed algorithm, optimization of the fuzzy controller for balancing the inverted pendulum system [6], where a free-falling pole is mounted on a cart that is controlled by an actuator, is considered here. The control objective is to produce an appropriate actuator force to control the motion of the cart so that the pole can be balanced in the vertical position. Given that no friction exists in the system, and let $x_1 = \theta$ and $x_2 = \dot{\theta}$, then the state equation can be expressed as

$$\begin{aligned} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= \frac{(M+m)g\sin x_1 - (F + mlx_2^2 \sin x_1)\cos x_1}{\{4/3(M+m) - m(\cos x_1)^2\}l} \end{aligned} \tag{1}$$

where M (mass of the cart) is 1.0Kg, m (mass of the pole) is 0.1Kg, l (half length of the pole) is 0.5m, g (gravity acceleration) is 9.8m/s^2, and F is the applied force in Newton. In this experiment, the following performance index is used

$$Q = \sum_{i=1}^{q} [e_i^2 + \dot{e}_i^2] \tag{2}$$

where q is the number of input-output pairs.

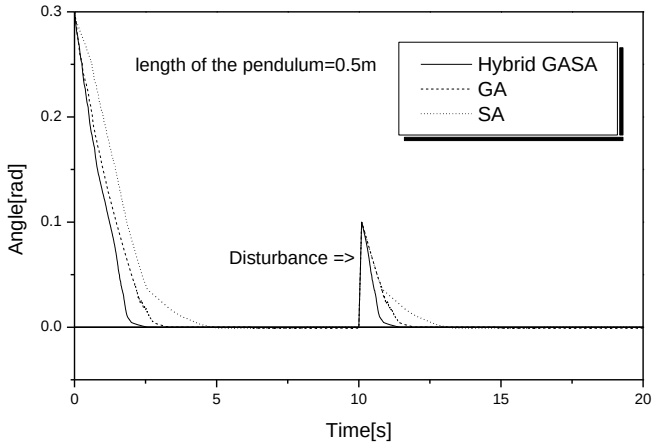

Fig. 2. Control results of the optimized fuzzy controller

The experiments for GA, SA, and proposed algorithm are taken into account to show the effectiveness of the proposed algorithm. Fig. 2 shows averaged control result of the inverted pendulum obtained by the optimized fuzzy controller when each algorithm is executed 10 times, independently. In this figure, the initial state, which is the initial values of the pendulum angle and the angular velocity, is the same as the optimization process, which is 0.3rad and zero, respectively. The disturbance of

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0.1rad is added to the pendulum angle at 10.0s. The result, in this figure, shows that the control performance obtained by the proposed algorithm is superior to GA and SA in convergence time and disturbance rejection.

4 Conclusions

In this paper, SA-selection that is modified version of SA was applied to tournament selection-based GA effectively without increasing the number of performance evaluation per generation. The experimental results showed that the proposed algorithm is superior to GA and SA in terms of learning speed and accuracy.

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