A Comparison of Genetic Algorithm Methods in Aerial Spray Deposition Management

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Abstract

In this paper, we describe several genetic algorithm methods to deal with the spray parameter optimization problem, and compare them with the original heuristic method SAGA.

1 SUMMARY

SAGA (Spray Advisor using Genetic Algorithm) was developed to heuristically search for an optimal or near-optimal set of input parameters needed to achieve a certain aerial spray deposition (Potter et al., 2000). It is a typical parametric design problem, in which the genetic algorithm evolves the spray parameters in a continuous domain, and the simulation engine evaluates the solution. The search space is rather huge, so the simple GA has difficulty converging to a global optimum.

First, we developed SAGA2 from SAGA. The original generational genetic algorithm is replaced by a steady-state genetic algorithm. The original roulette wheel selection is replaced by tournament selection. Instead of using a single type of crossover and mutation operator, in SAGA2 we combine several kinds of crossover and mutation operators and apply them with different probabilities. Second, we developed SAGA2NN from SAGA2. SAGA2NN generates the initial population from a large pool of individuals. In order to save computation time, it uses a neural network to approximate the fitness. The learning rule of the neural network is backpropagation with momentum. SAGA2NN also applies this method in the process of crossover and mutation. Then, we developed SAGADO by applying GADO (Genetic Algorithm for Design Optimization) in this problem. GADO is a general-purpose approach to solving the parametric design problem (Rasheed, 1998). Simulated annealing is also a widely used global stochastic optimization technique. In order to compare its performance with the genetic algorithm, we developed SASA based on simulated annealing. The cooling schedule adopted is geometric cooling. The temperature is updated using the formula: $Ti+1 = \alpha Ti$ ($\alpha \in (0, 1)$).

2 RESULTS AND ANALYSIS

We ran these methods on three practical spray parameter specifications provided by Forest Service managers. Each method ran five times with different random seeds. Evolution process of one of these parameter settings is shown in Fig. 1. SAGA2 and SAGADO outperform SAGA in all experiments. It shows that exquisite choice of type of GA, selection, crossover and mutation operator can boost GA performance. SAGA2NN converges very fast, which is useful in real aerial spray applications. We hoped it could achieve even better results, but our experiments don't show that. We think the reason is that the advantage of the neural network is counteracted by premature convergence of the genetic algorithm. SASA performs much poorer than the genetic algorithm methods. It shows that genetic algorithms perform better than simulated annealing in an extremely complicated domain such as aerial spray deposition management.

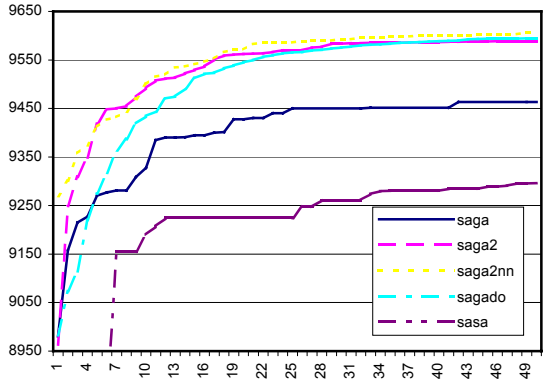

Fig. 1 Evolution Process of Parameter Setting III

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