Search Step Size Control in Fast Evolutionary Programming

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The paper proposes three approaches to controlling the search step size in fast evolutionary programming (FEP), and then evaluates their performance on a number of benchmark problems. Through adapting the parameter t in Cauchy mutation, mixing different mutation operators, and adopting cooperative coevolution, FEP becomes more robust while maintaining the fast convergence rate.

The first approach to controlling search step size in FEP is to use different t in the Cauchy density function. The larger value t is, the longer jump a Cauchy mutation generates. A set of experiments have been carried out on FEP using different t values in order to investigate how different parameter t impact on the performance of FEP.

These results show that $t = 1$ was not the optimal value for the seven benchmark problems. The optimal t is problem-dependent. One way to deal with this issue is to use self-adaptation so that t can gradually evolve towards its near optimum although its initial value might not be optimal.

The second approach, called IFEP, to controlling search step size in FEP is to use both Cauchy mutation and Gaussian mutation. IFEP differs from FEP slightly. Instead of using Cauchy mutation alone in FEP, IFEP generates two offspring from each parent, one by Cauchy mutation and the other by Gaussian mutation. The better one is then chosen as the offspring. The rest of the algorithm is exactly the same as FEP.

The analytical results explain why IFEP achieved better results than FEP for most of the benchmark problems we tested, because the initial population was generated uniformly at random in a relatively large space and was far away from the global optimum on average. Cauchy mutation is more likely to generate larger jumps than Gaussian mutation and thus better in such cases. However, FEP would be less effective than IFEP near the small neighborhood of the global optimum because Gaussian mutation's step size is smaller (smaller is better in this case). The experimental results illustrate such behavior clearly.

The third approach to controlling search step size in FEP is to apply cooperative coevolution. When the dimensionality becomes large, FEP converges very slowly in comparison with classical EP (CEP). The reason that FEP's performance worsens as the dimensionality increases lies in its increasingly large search step sizes. FEP's search step size (driven by the search step size of the Cauchy mutation) increases as the dimensionality increases. When the search step size is larger than the optimal one, further increase in the step size can only deteriorate the search performance. With cooperative coevolution, FEP is applyed to a component of a vector rather than the whole vector, the problem of too large step size with high dimensionality does not exist. Furthermore, the robust and faster search capability of Cauchy mutation in one dimension can be fully explored by cooperative coevolution approach.

Two sets of experiments had been conducted for the cooperative coevolution of FEP. In the first set of experiments, the fitness of an individual in FEPCC was estimated by combining it with the current best individuals from each of the other populations to form a vector of real values, and applying the vector to the target function. To get a better evaluation, we can construct many vectors, and determine the fitness of an individual by evaluating the target function values of all vectors containing this individual. In the second set of experiments, The fitness of an individual is evaluated based on the average value of target function on eight randomly selected vectors.