A Technique for Improving the Convergence Characteristic of Genetic Algorithms and Its Application to a Genetic-Based Load Flow Algorithm

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Abstract. This paper is devoted to the development of a technique for the enhancement of the convergence of genetic algorithms. Based on the concept of solution acceleration, a technique is proposed and applied to a constrained-genetic-algorithm load-flow algorithm CGALF recently developed for solving the problem of evaluating the voltage profile and power flow in electric power networks. The enhanced CGALF algorithm is applied to a practical power system to illustrate the effectiveness of the developed method.

Keywords: genetic algorithms, optimisation, power system, load flow

1 Introduction

The evolutionary-based computational techniques have been shown to be capable of dealing with nonlinear optimisation problems. The powers of these techniques can also be enhanced by constraint handling methods [1] [3]. On the development of constraint handling techniques, the authors have previously developed a method [4], [5] to handle and to satisfy the equality constraints in a GA-based algorithm for solving the important problem of calculating the voltage profiles and the power flow patterns in highly interconnected power network systems. The speed of the evolutionary approach can be improved by developing some solution acceleration techniques.

This paper is devoted to the development of a technique for the enhancement of the convergence of genetic algorithms. The concept of accelerating the solution seeking process under the genetic algorithm environment is first introduced. Based on the concept, an acceleration technique is proposed. It is then applied to a constrained-genetic- algorithm load flow (CGALF) algorithm for solving the problem of evaluating the voltage profile and power flow in electric power networks. The CGALF algorithm [5] was developed by the authors and it does not contain any solution acceleration method. For completeness, the load flow problem and the CGALF algorithm are described in the paper. The method of incorporating the convergence enhancement technique into the CGALF algorithm is then presented. The enhanced CGALF algorithm is applied to a practical power system to illustrate the effectiveness of the developed method for improving the robustness of CGALF algorithm and for reducing the computational requirement.

2 Concept of solution acceleration under the GA environment

Solution acceleration techniques have previously been employed in iterative methods for the determination of solutions of unknown variables in a set of simultaneous equations. For example, in the iterative Gauss-Siedel load flow method [6], the accelerated solution of variable x at the pth iteration is estimated from its solutions at the pth and the $(p-1)th$ iterations according to

$$x_{ac}^{p} = x^{p-1} + \alpha(x^{p} - x^{p-1}) \tag{1}$$

where α is a constant coefficient. The acceleration mechanism is initiated by setting the value of α to a value greater than unity.

A concept of solution acceleration can also be established under the GA or evolutionary environment. Here the chromosomes in a population $P(g)$ at generation g are candidate solutions for the optimisation problem under consideration. The candidate solution in the fittest chromosome so far generated can be taken as the most appropriate solution S_b in the current generation g.

To enhance the convergence characteristic of GA and to accelerate the solution seeking process, the solutions in the other chromosomes in $P(g)$ are now moved closer to S_b. One of the ways to implement this concept is described in the following. Let S be the solution in a chromosome in $P(g)$. The difference between S_b and S is first formed. Then the difference is scaled and added to S_b to form the new chromosome. In this way, all the chromosomes in $P(g)$ can be accelerated. The accelerated chromosomes in $P(g)$ are used to produce the chromosomes in the next generation $P(g+1)$ by the genetic operators in the usual manner.

For a given problem or a class of problem, the value of the coefficient which is used to scale the difference between S_b and S can be estimated by (a) experiment, and (b) setting the value randomly within a specified range in the entire GA solution process.

The above solution acceleration concept and convergence enhancement technique have been applied to a genetic-based load flow algorithm recently developed by