Optimal management in regulation of adding materials in water distribution systems by multi-population genetic algorithm method

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Abstract

One of the greatest drawbacks of GAs is that they require a high number of function evaluations to achieve convergence. Each function evaluation entails a full extended-period simulation of the system, which is a computationally expensive process. The net result is that GA optimization is time consuming. For a large distribution system a GA optimization run can take up to a few days on a modern personal computer. In the study efficiency of GA operational optimization was improved through a hybrid method which combines the GA method with a hillclimber search strategy. Hill climber strategies complement GAs by being efficient in finding a local optimum two hillclinber strategies, the Hooke and Jeeves and Fibonacci methods, were investigated. The hybrid method proved to be superior to the pure GA in finding a good solution quickly, both when applied to a test problem and to a large existing water distribution system.

Keywords: Hooke –Jeeves, Fibonacci, Genetic Algorithms, Hill climber strategies

Introduction

The problem of finding the optimal operating strategy is far from simple: both the electricity tariff and consumer demand can vary greatly through a typical operating cycle; minimum levels of water have to be maintained in tanks to ensure reliability of the supply, and the number of pump switches in an operating cycle has to be limited to avoid excessive pump maintenance costs. Added to these factors is the fact that the hydraulic behavior of water distribution systems is highly nonlinear, making computer modeling a complex and time-consuming process. Finally, the number of possible operating strategies becomes vast for systems with more than a few pumps and tanks.

Various optimization techniques have been applied to the operational optimization problem, including linear programming (Jowitt and Germanopoulos 1992; Burnell et al. 1993), nonlinear programming (Chase and Ormsbee 1993; Yu et al. 1994), dynamic programming (Lansey and Awumah 1994; Nittivattananon et a1. .1996), fuzzy logic (Angel et al. 1999), nonlinear heuristic optimization (Ormsbee and Reddy 1995; Leon et al. 2000), flexible constraint satisfaction (Likeman 1993) and genetic algorithms (Mackle et al. ١٩٩٥; Savic et al. ١٩٩٧; Boulos et al. ٢٠٠٠).

In most operational optimization methods, the optimization problem is simplified through assumptions, discretization or henristic rules. Such simplification makes it easier for specific optimization methods to determine the optimal solution, but introduces bias into the solution by excluding a large number of potentially good Solutions. Genetic algorithms (GA.s) do not require such simplification measures, giving them a significant advantage in finding a near global optimal solution over most other optimization methods.

A hybrid optimization strategy was developed by combining a genetic algorithm search with a hillclimber search method. GAs have very good initial convergence rates, but are less efficient once the GA has found a near-optimal solution. Local search methods, on the other hand, are good at converging on the local optimum from a nearby starting point, but are not able to jump to other possibly better, areas of solution space. By combining the GA strategy with a local search strategy, the advantages of both methods are exploited to produce an optimization method which is both reliable and fast.The ideal optimization method is one which is both reliable in finding a near-global optimal solution, and fast in converging on that solution. However, these goals are often in conflict with each other, forcing a trade-off in selecting the parameters for the optimization method. When applied to water distribution systems, for instance, in an emergency situation, it is often more important to find a good solution speedily than it is to find the global optimum solution. For this reason the hybrid method was developed with the main emphasis on convergence speed rather than reliability.