PRELIMINARY ANALYSIS OF MULTI-OBJECTIVE GENETIC ALGORITHM APPLICATION FOR MULTIRESERVOIR SYSTEM

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Multireservoir system consists of several reservoirs which are connected serially or parallel in the same basin. To optimize such a complex multireservoir system, the dynamic programming (DP), linear programming (LP) and non-linear programming (NLP) have been widely applied to real problems. Recently, there has been an increasing interest in a biologically motivated adaptive system for solving optimization problems. Genetic algorithms (GAs) are one of the most promising techniques in natural adaptive system field, and receiving many attentions because of their flexibility and effectiveness for optimizing complex systems.

GAs are not restricted by a number of dimensions since computer memory increases by dimensions linearly, not exponentially. Thus, there is no 'curse of dimensionality' occurred in DP. Conventional optimization techniques such as DP, LP, and NLP are not proper to multi-objective optimization, because these methods use a "point-by-point approach" that calculates a single optimal solution in one simulation run. However, GAs use a set (population) of solutions instead of a single solution, "population-based approaches", thus it is easy to solve multi-objective problems. This is one of the most striking differences between classical optimization methods and GAs.

In this paper, multi-objective GAs are applied to optimize multireservoir system in the Han River basin in South Korea. Multi-objective GAs, which have many attractive features, have had only limited applications to the multireservoir system optimization. The present work focuses on the application of multi-objective GAs to the multireservoir system optimization, and which distribution index of NSGA-II is the best for multireservoir optimization. The solutions of multi-objective GAs yield a trade-off curve identifying a population of points that define the Pareto-optimal solutions to the problem. Nondominated sorting approach is used. Maintaining a diverse set of solutions in the Pareto-front is achieved by sharing. Crossover and mutation operators are used and tournament selection is applied, and chromosomes are coded by real values.

The developed MOGAs are applied to multi-reservoir system in Han River basin in South Korea. The objective functions consist of two objectives which are the sum of storage and the difference between release and water supply. Crossover rate is 0.9 and mutation rate is 1/36. The number of chromosome and the iteration number are 500 and 36 real-coded variables are used to make chromosome.

Pareto-optimal solutions are a group of nondominated solutions with rank of 1. If multiple objectives used in simulation are conflicting objectives with each other and selected well, Pareto-optimal solutions form trade-off curve. However, the inappropriate objective function is chosen, Pareto-optimal solutions are gathered into one point or small region, not distributed in the Pareto-front. In this case, the objective functions should be selected again. The two trade-off curve using distribution index 3.0 and 3.8 show generally well shaped Pareto-front of Min-Min optimization problem. However, the result using distribution index 3.0 show the better distributed Pareto-solutions in front. Thus, the distribution index 3.0 is selected in this study.

In order to examine the decision space, three points are chosen from the Pareto-optimal solutions. Coefficient of variation (VAR) is calculated to discriminate which month has the power to improve or deteriorate objective function values. Decision variables which exhibit significant change are observed at first, and called as critical decision variables. A full investigation of decision space for identifying critical decision variables suggests the releases in May, June, and August at the Hwacheon reservoir are the major critical decision variables, while the remaining critical variables are minor ones. The patterns of the storages at the Hwacheon reservoir are examined to check the effect of critical variables. The decision-maker can obtain the desired objective function value and determine how best to adjust the decision variables using critical decision variables.

MOGAs have been demonstrated to be an effective solution technique for solving multireservoir system optimization. The approach can efficiently identify Pareto-optimal solutions (a trade-off curve) that exist for a multi-objective optimization problem. The trade-off curve can be used by a decision maker to obtain an appropriate solution considering the conflicting objectives which are to maximize the storages and minimize the water shortages.

Some improvements over the algorithm used in this study are possible. Firstly, the releases are correlated to the next stage serially, thus if crossover and mutation operator with correlation are developed, the performance of MOGAs could be improved. Another future work could explore the application of MOGAs involving more than two objectives. To manage more than two objectives, a sub-ranking mechanism, which can sort chromosomes within same rank and prevent chromosomes from premature, is necessary.