

# **Real-Coded Genetic Algorithm Parameter Setting for Water Distribution System Optimisation**

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The management of Water Distribution Systems (WDSs) involves making decisions about various operations in the network, including the scheduling of pump operations and setting of disinfectant dosing rates. There are often conflicting objectives in making these operational decisions, such as minimising costs while maximising the quality of the water supplied. Hence, the operation of WDSs can be very difficult, and there is generally considerable scope to improve the operational efficiency of these systems by improving the associated decision making process. In order to achieve this goal, optimisation methods known as Genetic Algorithms (GAs) have been successfully adopted to assist in determining the best possible solutions to WDS optimisation problems for a number of years.

Even though there has been extensive research demonstrating the potential of GAs for improving the design and operation of WDSs, the method has not been widely adopted in practice. There are a number of reasons that may contribute to this lack of uptake, including the following difficulties: (a) developing an appropriate fitness function that is a suitable description of the objective of the optimisation including all constraints, (b) making decisions that are required to select the most appropriate variant of the algorithm, (c) determining the most appropriate parameter settings for the algorithm, and (d) a reluctance of WDS operators to accept new methods and approaches.

While these are all important considerations, the correct selection of GA parameter values is addressed in this thesis. Common parameters include population size, probability of crossover, and probability of mutation. Generally, the most suitable GA parameters must be found for each individual optimisation problem, and therefore it might be expected that the best parameter values would be related to the characteristics of the associated fitness function.

The result from the work undertaken in this thesis is a complete GA calibration methodology, based on the characteristics of the optimisation problem. The only input required by the user is the time available before a solution is required, which is beneficial in the WDS operation optimisation application considered, as well as many others where computationally demanding model simulations are required. Two methodologies are proposed and evaluated in this thesis, one that considers the selection pressure based on the characteristics of the fitness function, and another that is derived from the time to convergence based on genetic drift, and therefore does not require any information about the fitness function characteristics.

The proposed methodologies have been compared against other GA calibration methodologies that have been proposed, as well as typical parameter values to determine the most suitable method to determine the GA parameter values. A suite of test functions has been used for the comparison, including 20 complex

mathematical optimisation problems with different characteristics, as well as realistic WDS applications.

Two WDS applications have been considered: one that has previously been optimised in the literature, the Cherry Hills-Brushy Plains network; and a real case study located in Sydney, Australia. The optimisation problem for the latter case study is to minimise the pumping costs involved in operating the WDS, subject to constraints on the system, including minimum disinfectant concentrations. Of the GA calibration methods compared, the proposed calibration methodology that considered selection pressure determined the best solution to the problem, producing a 30% reduction in the electricity costs for the water utility operating the WDS.

The comparison of the different calibration approaches demonstrates three main results:

1. that the proposed methodology produced the best results out of the different GA calibration methods compared;
2. that the proposed methodology can be applied in practice; and
3. that a correctly calibrated GA is very beneficial when solutions are required in a limited timeframe.