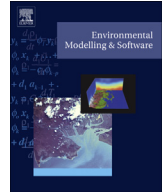




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Preface

Thematic issue on Evolutionary Algorithms in Water Resources[☆]



Evolutionary Algorithms (EAs) and other similar optimisation approaches have become very popular in the water resources research literature over the last two decades. One reason for the emergence of EAs in the literature is that they use evolutionary principles found in nature, “evolving” to find better solutions to complex water resources problems. Another reason is that evolutionary optimisation provides a natural extension to the use of simulation models, as EAs simply “bolt onto” existing models. Consequently, the resulting optimisation process is very intuitive, as the way EAs try different solutions and then learn from the outcomes of these trials is similar to the process humans adopt when manually “optimising” or adjusting solutions to problems via a simulation based approach. The only differences when EAs are used are that the decisions as to which options to try are made with the aid of evolutionary operators, rather than human judgement, intuition and experience, and that the number of options considered is much larger. Moreover, outputs of the EA process are equivalent to outputs of trusted simulation models. Therefore, the optimisation results from EAs tend to have more credibility than those obtained using alternative approaches, such as mathematical programming, since the latter generally require gross simplifications of problem representation.

Another attractive feature of EAs is that they are not necessarily prescriptive in the sense of suggesting “the” optimal solution. This is because they work with populations of solutions and therefore produce a number of near-optimal solutions, which might be similar in objective function space, but quite different in solution space. This enables consideration of factors other than those captured in the mathematical formulation of the optimisation problem when selecting the solution to be implemented. As a result of the loose coupling between the optimisation engine, which decides which parts of the solution space to explore, and the simulation model, which evaluates how well the selected solutions perform in relation to the objectives and/or whether constraints have been violated, EAs can deal with discontinuities and nonlinearities with ease, as long as these have been captured appropriately in the simulation model. Another advantage of EAs is that they are well suited to multi-objective problems, as they can evolve optimal trade-offs between objectives (i.e. Pareto fronts) in a single optimisation trial.

Given the fascination and intrigue associated with the ability to use evolutionary processes to optimise water resources problems, the practicality and intuitiveness associated with being able to make use of existing simulation models and the advantage of being

able to solve complex problems, it is not surprising that research involving EAs has received significant attention. This research has demonstrated the undoubted potential of EAs in the sense that they can be applied to and perform well in a wide range of application areas. In addition, significant research effort on the development and testing of different types of EAs, evolutionary operators and algorithm parameterisation has resulted in the ability to find better solutions with reduced computational effort. However, while there are pockets of research that continue to significantly push the boundaries of knowledge in this field, there is also a large amount of research that continues to re-visit the same themes. For example:

- There continue to be a large number of papers on using an ever increasing number of EA variants for solving an ever increasing number of water resources problems, with little focus on *understanding why* certain algorithm variants perform better for certain case studies than others. In addition, there is no consistency in algorithms, algorithm implementations, performance criteria and case studies in the papers. The above factors make it extremely difficult to draw conclusions that are applicable to the wider research field and enable meaningful guidelines for the application of different algorithms to be developed.
- There continue to be a large number of studies that use theoretical or very simplistic case studies. However, there are significant challenges associated with the application of EAs to real-world problems that need to be addressed in order to increase their uptake in industry.

In order to counteract potential repetition and stagnation in this field, [Maier et al. \(2014\)](#) identified a number of research questions that should be addressed. They suggest that the main areas in which research efforts should be directed include improving our understanding of algorithm performance and how to apply EAs to real-world problems, as summarised in [Table 1](#). The 18 papers in this thematic issue begin to address some of these research questions, as summarised in [Table 2](#) and discussed below.

[Gibbs et al. \(2015\)](#) develop a relationship between metrics that quantify fitness function characteristics and the number of generations needed for a genetic algorithm to converge in a pre-determined number of generations for a large number of synthetically generated test problems with different attributes. This relationship is then validated on two water distribution system optimisation problems, including the Cherry Hill-Brushy Plains network, which is a commonly used test problem, and the optimal operation of the Woranora water distribution near Sydney, Australia, which is a real-world case study. The ability to select

[☆] Special Issue on Evolutionary Algorithms.

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