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PENALTY-FREE SELF-ADAPTIVE SEARCH SPACE REDUCTION METHOD FOR MULTI-OBJECTIVE EVOLUTIONARY OPTIMIZATION OF WATER DISTRIBUTION NETWORKS

Tiku Tanyimboh

University of the Witwatersrand, Johannesburg, South Africa
tiku.tanyimboh@wits.ac.za

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Abstract: Evolutionary optimization approaches such as genetic algorithms (GAs) are being used increasingly in the optimization of water distribution networks. However, the size of the search or solution space is highly dependent on the size of the network and number of commercially available pipe diameters adopted. Consequently, the number of function evaluations or hydraulic simulations required to identify optimal and/or near-optimal solutions can be extremely large. For real-world networks with hundreds of pipes or more, the process can be extremely time-consuming as the GA might require millions of computationally expensive function evaluations or hydraulic simulations. It is, therefore, highly desirable to reduce the search or solution space in order to speed up the optimization process. Hitherto, not much work with valuable results has been done on this aspect and few publications present methods for reducing the GA search space. The new approach developed and assessed was based on the importance of every path through the network, which is included in the entropy function. Unlike the previous approaches in the literature, the method proposed does not involve pre-processing and initializing or setting the reduced solution space of the diameters beforehand. Instead, based on reliability and resilience considerations, the reduced solution space is determined using maximum entropy principles. The new methodology proposed comprises two main phases. In the first phase, the entire solution or search space is explored without restriction until a feasible solution is identified. In the second phase, exploitation is intensified by updating the active solution space in every generation. This is achieved by means of a reference solution that is updated in every generation in the second phase. The reduced set of candidate diameters considered in each generation in the second phase is defined relative to the reference solution. The algorithm has been applied to an established benchmark network previously used in search space reduction studies. Detailed comparisons of the Pareto-optimal fronts from the full and reduced solution spaces (RSS) were carried out. Solutions obtained using RSS dominated and clearly outperformed the solutions based on the full solution space by being less expensive for similar entropy values. Another significant advantage of the proposed maximum entropy based RSS approach is that it limits the search space to the areas that are very close to the boundaries between the feasible and infeasible regions. Consistently good results were achieved in terms of the computational efficiency and quality of solutions as a result.