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Optimizing long-term reservoir operation through multi-tier interactive genetic algorithm

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For long-term reservoir planning and management problems, the reservoir optimal operation in each period is commonly searched year by year. The search domain for the initial reservoir storage for each year is limited to certain ranges, the over-year conditions cannot be adequately delivered over time, and therefore such operation fails to integrate the conditions of all the considered years as a whole situation. In this study, a multi-tier interactive genetic algorithm (MIGA) was applied to searching the long-term reservoir optimal solution. MIGA can decompose a large-scale task into several small-scale sub-tasks with GAs applied to each sub-task, where the multi-tier optimal solutions mutually interact among individual sub-tasks to produce the optimal solution for the original task. In such way, the long-term reservoir operation task can be divided into several independent single-year tasks; therefore, the difficulty of the optimal search for a great number of decision variables can dramatically be reduced. The Shihmen Reservoir in northern Taiwan was used as a case study, and the long-term optimal reservoir storages (decision variables) were investigated. The objective was to best satisfy water demands in the downstream area; and a 10-day period, the traditional time frame in Chinese agricultural society, was used as a time step. According to this time scale, there were two cases with different time intervals (variables): Case I- five relative drought consecutive years (2001 to 2006) with 180 variables (i.e. $36\times5=180$); and Case II- twenty consecutive years (1986 to 2006) with 720 variables (i.e. $36\times20=720$). For the purpose of comparison, a simulation based on the reservoir operating rule curves and a sole GA search would be implemented to find the solutions. In Case I, despite the number of the decision variables which was 180, the sole GA could still well search the optimal solution. In Case II (720 variables), the sole GA could not reach the optimal solution. The results indicated that MIGA had better performance than the sole GA in both cases; and the improvement rate of fitness values increased more than 20% and the computation time decreased almost 80% in a 20-year long-term operation case. MIGA would require only very small numbers of generation number and population size to quickly reach an optimal solution. The results demonstrated that MIGA was far more efficient than the sole GA and could successfully and efficiently increase the possibility of achieving the optimal solution, especially in the search of the optimal solution to a problem with a large number of variables.