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Handling time-expensive global optimization problems through the surrogate-enhanced evolutionary annealing-simplex algorithm

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In water resources optimization problems, the calculation of the objective function usually presumes to first run a simulation model and then evaluate its outputs. In several cases, however, long simulation times may pose significant barriers to the optimization procedure. Often, to obtain a solution within a reasonable time, the user has to substantially restrict the allowable number of function evaluations, thus terminating the search much earlier than required by the problem's complexity. A promising novel strategy to address these shortcomings is the use of surrogate modelling techniques within global optimization algorithms. Here we introduce the Surrogate-Enhanced Evolutionary Annealing-Simplex (SE-EAS) algorithm that couples the strengths of surrogate modelling with the effectiveness and efficiency of the EAS method. The algorithm combines three different optimization approaches (evolutionary search, simulated annealing and the downhill simplex search scheme), in which key decisions are partially guided by numerical approximations of the objective function. The performance of the proposed algorithm is benchmarked against other surrogate-assisted algorithms, in both theoretical and practical applications (i.e. test functions and hydrological calibration problems, respectively), within a limited budget of trials (from 100 to 1000). Results reveal the significant potential of using SE-EAS in challenging optimization problems, involving time-consuming simulations.