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Optimal sensor placement method for wastewater treatment plants based on discrete multi-objective state transition algorithm

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Municipal wastewater treatment plants (WWTPs) reuse domestic sewage, industrial wastewater, and rainfall runoff to realize sustainable utilization of fresh water resources. In order to guarantee the safety, reliability, and profitability of the WWTP, efficient process monitoring and control is becoming increasingly important. However, due to the economic and technical requirements, it is infeasible to place sensors at every process parameter location. Therefore, it is necessary to design the optimal sensor placement scheme which leads to maximum information gain about the plant conditions. Practical issues present in the WWTP, such as harsh physical conditions, fluctuation of water quantity, and variability in process parameters, make the optimal sensor placement problem an especially complicated one. Furthermore, sensors placement problem contains multiple objectives with complex nonlinear relationship. This study focuses on obtaining the optimal flow sensor placement scheme of the WWTP in terms of cost, information richness and redundancy. First, based on the graph theory and structural observability and redundancy criteria, a WWTP system model is constructed. Next, an industrial condition weighting factor setting strategy is introduced to measure the importance of the variables in different processing units, transforming the optimal flow sensor placement problem in the whole process into a discrete multi-objective optimization problem. Then, a novel metaheuristic method named discrete multi-objective state transition algorithm (DMOSTA) is proposed to obtain optimal trade-off solution set. Finally, an evaluation strategy is applied to select the best flow sensor placement scheme from the solution set. The proposed method is applied to three WWTPs with different dimensions. Comparative results show that the optimal flow sensor placement scheme based on the proposed method has the best comprehensive performance in regard to senor cost, process variable observability, sensor redundancy, and computational cost.